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MATHEMATICS.—*The role of the concept of equivalence in the study of physical and mathematical systems.*[1] RICHARD STEVENS BURINGTON, Bureau of Ordnance, Navy Department.

Foreword.—Many mathematicians as well as engineers and physicists sometimes fail to recognize the great principles underlying mathematical reasoning and methods that permeate their particular fields. Instead, they are apt to turn their attention solely to the formalism of the techniques involved. This is a tendency to be guarded against and one to which professional people and educators should give continued attention, particularly in the teaching of mathematics, science, and engineering. This paper, therefore, urges wider consideration of mathematical principles and methods by scientists and engineers, whether or not they are primarily interested in mathematics, and gives examples with reference to one well-known mathematical concept.[2]

1. *Introduction.*—The concept of equivalence lies at the heart of nearly every transaction, physical theory, and mathematical system. The literature abounds in such phrases as

(P) A is equivalent to B,

which, unless properly defined, are often meaningless or misleading (e.g., "an electric organ is equivalent to a pipe organ"; "one 1937 dollar is equivalent to 60 cents").

When S is a physical system, the elements $A, B, \ldots$ of the system are identified with specific physical objects, quantities, . . . , and the types of equivalence relations used must be carefully defined. Each such definition constitutes a separation of $A, B, \ldots$ and the associated physical picture into classes. Such separation may be of considerable physical significance, each type of equivalence often having associated with it an extensive physical theory. Thus, in electrical theory are defined: "equivalent m-pole networks," involving the "congruence" of certain matrices characterizing the physical system; "symmetric components," involving the "similarity" of certain matrices; etc.

In the study of physical systems, perfect, or approximate isomorphic (abstractly identical) systems play a fundamental role. Equivalent physical (or mathematical) models are integral parts of the methods used (e.g., as in hydrodynamic similitude theories, . . .).

Considerable progress has been made by mathematicians in extending the theory of equivalence relations. To what extent these abstractions will be of value in the applied fields remains to be seen. This much is clear. A consciousness of the concept of equivalence is of real value. It helps to clarify problems. It provides a means of attack. The involved details of the modern abstract theories of equivalence

[1] This paper was prepared from the manuscripts of two addresses by the writer: *The concept (and misconcept) of equivalence*, presented to the Philosophical Society of Washington on January 18, 1947, and *On the role of equivalence in pure and applied science and in practical and everyday life*, presented to the Oberlin Mathematics Club, Annual Banquet Meeting, on May 17, 1946. The writer wishes to express his appreciation of the many constructive suggestions and critical comments made during the preparation of the paper by his colleagues Dr. D. C. May, Mrs. A. B. McCaleb Nazary, and Miss A. Madsen, of the Bureau of Ordnance. The opinions expressed herein are those of the author and not necessarily those of the Navy Department. Received June 20, 1947.

[2] See also BURINGTON, RICHARD S., *New frontiers*, Science **101**: 313–320. Mar. 30, 1945.

will be in themselves of little value in practical problems unless a penetrating inquiry into the economic, physical, or other pertinent background of the problem at hand is made.

2. *The phrase (P) must be defined.*—The phrase

(P) A is equivalent to B,

to have a well-defined meaning, requires appropriate definitions of the entities A and B, as well as a precise statement as to the meaning to be attached to the phrase "is equivalent to" as used in relation to A and B. Thus, the use of the phrase (P) should be accompanied by adequate and proper definitions. For example, in the phrase "1937 dollar is equivalent to 60 cents" it is not known what a "1937 dollar" is, what "60 cents" is, or what "is equivalent to" means. One would be at a loss to explain what the phrase means. Likewise, the phrase "an electric organ is equivalent to a pipe organ" is questionable since there is nothing in the statement indicating in what sense the two organs are considered to be equivalent. Does the phrase mean that the two organs can generate the same level of noise as measured (in some manner or other) in decibels in a given auditorium; does it mean that each of the two instruments can be used to play church music; or does it mean that their tonal potentialities are comparable to each other, and so on? The list need not be extended further, for the reader can no doubt contribute hundreds of similar examples and queries.

3. *Importance of such statements as (P).*—The importance of such statements as (P) becomes evident when one realizes that the notion of equivalence lies at the very basis of nearly every transaction and of nearly every mathematical system or formulation of a physical theory. For example, in order that the statement "3 feet = 1 yard" be understood, the concept of equivalent lengths must be thoroughly understood, and the fact that there exists standards of length, such as 1 foot and 1 yard, must be appreciated. A proper understanding of such statements as "$2\times3=6$" requires an accurate theory containing adequate definitions. Surely the operation of multiplying 2 by 3 is not "the same" as 6. If not "the same," then what is meant by the statement that $2\times3=6$? A complete answer to such questions requires a rather extensive treatment of the foundation of the theory of numbers. This will not be attempted here.

4. *Historical remarks on the definitions of equality.*—As man first attempted to discover the reasons for things, he began using the concepts of equivalence and identity. The philosophical considerations of these concepts have been debated at length. This phase of the subject is too vast to enter into here.

Leibnitz, in *Opera philosophica* (Erdmann) gave the definition: "Two things are called equal if, in every expression, one may be replaced by the other." This definition is open to much criticism.

Whitehead and Russell, in their *Principia mathematica* (1910), set forth a number of sets of postulates which an identity or an equality should satisfy. These postulates were developed over a period of time and were not original with Whitehead and Russell. A certain set of these postulates is, essentially, as follows:

I. Given any two elements A and B, either $A=B$ or $A\neq B$. (Determinative property.)
II. $A=A$. (Reflexivity property.)
III. If $A=B$, then $B=A$. (Symmetrical property.)
IV. If $A=B$ and $B=C$, then $A=C$. (Transitivity property.)

The critical student might well object to the use of these postulates as the basis for definitions of identity or equality. However, they are a great improvement over earlier definitions.

As MacDuffee[3] has pointed out, the teleological concept of equality has been favored by many mathematicians—until recently by most of them. (Teleology: the philosophical study of evidence of a coordinated creative design in nature.)

It should be noted that equality is sometimes taken as one of the basic principles of logic and not subject to further definition or analysis.

[3] MacDuffee, C. C., *Different kinds of equality*, The Mathematics Teacher, Jan. 1936: 10–13.

The newer approach to the subject is to define a new type of equality for the elements of some system. When this is done, it must be shown that the equality relation as defined actually has the required properties I, . . . , IV. This removes the concept completely from philosophical study.

5. *Abstract definition of the phrase* (*P*).—The abstract formulation of the notion of equivalence has been carefully studied by mathematicians. A brief outline of one such formulation seems appropriate for the purpose of this discussion, the formulation given being one commonly used in defining equivalence in algebraic systems, and in many formulations of physical theories.

One abstract formulation of this concept of *equivalence* may be embodied in the following four postulates and associated definitions.

Let $A, B, C, \ldots$ be elements in the fixed system S being considered (such as abstract entities, quantities, . . .), and suppose a possible relationship that may occur between these elements $A, B, C, \ldots$ is defined in some manner or other. Suppose that when A and B are so related, the relationship is indicated by the symbol $\underline{\underline{\mathrm{E}}}$, and the expression $A \underline{\underline{\mathrm{E}}} B$ is written; and that when A and B are *not* so related, the fact is indicated by the symbol $A \overset{\mathrm{E}}{\neq} B$. Then the relationship expressed by the symbol $A \underline{\underline{\mathrm{E}}} B$ is known as the *equivalence* relation provided that it is defined to satisfy the following four *properties:*

I. *Determination.* For any pair of elements A and B of S the relation $A \underline{\underline{\mathrm{E}}} B$ either holds or does not hold.
II. *Reflexivity.* For any A one has $A \underline{\underline{\mathrm{E}}} A$.
III. *Symmetry.* When $A \underline{\underline{\mathrm{E}}} B$, then $B \underline{\underline{\mathrm{E}}} A$.
IV. *Transitivity.* When $A \underline{\underline{\mathrm{E}}} B$ and $B \underline{\underline{\mathrm{E}}} C$, then $A \underline{\underline{\mathrm{E}}} C$.

A is said to be equivalent to B if $A \underline{\underline{\mathrm{E}}} B$ *is an equivalence relation.*

[The symbol $\underline{\underline{\mathrm{E}}}$ is to be read "is equivalent to"; the symbol $\overset{\mathrm{E}}{\neq}$ is to be read "is not equivalent to."]

Every such definition of equivalence, which is ordinarily *not unique* for the given system, constitutes a division of the elements $A, B, C, \ldots$ into classes.

The determinative property (I) suggests the existence of at most two cases for the definition of equivalence used, and that the relation is *determinative.*

The reflexive property (II) is an extension of the earlier equivalence relation known as the *identity.*

The symmetric property (III) insures that the relation of equivalence is *symmetric.*

The transitive property (IV) is an extension of the old concept "things equal to the same thing are equal to each other."

The special equivalence relation $A \underline{\underline{\mathrm{U}}} B$, which is defined to hold for *any* pair of elements A and B is called the *universal relation.*

The equivalence relation $A \underline{\underline{\mathrm{I}}} B$, which holds only when A and B are the same or "identical elements," is called the *identity* or *unit relation.*

A serious study of systems which satisfy these properties would be a large undertaking. It would include study of systems that do not satisfy all these properties. Such an undertaking would involve a great many fields of mathematics. This will not be attempted in the present paper.

6. *Equality and equivalence.*—It should be remarked that the formulation given in paragraph 5 has been used to define the statement

(E) A is equal to B.

For the purposes of this paper the fine points of reasoning which have led some scholars to use the above postulates to define "is equal to" and others to use them to define "is equivalent to," and to distinguish between "is equal to" and "is equivalent to," need not be discussed here.

7. *Ordinary plane* (*Euclidean*) *geometry.*—Ordinary plane geometry when viewed from the newer point of view is crudely as follows:

(1) The elements of this geometry are points and lines forming geometric figures.
(2) The concept of superposition is taken for granted in such an intuitional geometry.
(3) Two geometric figures A and B are called *congruent* (equal) if one figure may be rotated and translated until it is brought into coincidence with the other figure.
(4) Given any two geometric figures A and B:
   (*a*) Either these figures can be made to coincide ($A \underline{\underline{\mathrm{E}}} B$), or they can not be made

to coincide ($A \underline{\underline{E}} B$). Thus the property of determination holds for the geometry under consideration.

(b) Every figure can be superimposed upon itself. ($A \underline{\underline{E}} A$). Hence the property of reflexivity holds.

(c) If one figure can be made to coincide with a second figure, ($A \underline{\underline{E}} B$), then the second can be made to coincide with the first, ($B \underline{\underline{E}} A$). Thus the property of symmetry holds.

(d) If one figure can be made to coincide with a second figure, ($A \underline{\underline{E}} B$), and the second figure can be made to coincide with a third figure, ($B \underline{\underline{E}} C$), then the first can be made to coincide with the third, ($A \underline{\underline{E}} C$). Hence, the property of transitivity holds.

Therefore, ordinary plane (Euclidean) geometry satisfies the four required properties of an equivalence relation as defined in paragraph 5.

(5) In this type of geometry, the geometry of congruent figures is the study of those properties relating to the figures which remain invariant under the equivalence relation of congruence. (Thus, if two triangles are congruent, their areas are equal.)

8. *Other examples from elementary geometry.*—In addition to the example given above there are many other simple examples of equivalence to be found in elementary geometry. Thus, in Euclidean geometry, two polygons A and B may be equivalent in the sense that they have equal areas, but they may or may not be equivalent in the sense that they have the same number of sides or angles, and so on.

Again, any two proper conics, A and B, are equivalent (that is $A \underline{\underline{E}} B$) in the sense that A may be transformed into B by means of a projective transformation, while on the other hand A may or may not be equivalent to B in the sense that A may be transformed into B by means of a translation and rotation.

In general, in geometry, whether two geometric quantities are equivalent can be determined by calculating certain numbers known as invariants, which are associated with the objects under study. In such cases, if certain relative invariants for an object A are identical, respectively, to the corresponding invariants for the object B, the object A is equivalent to the object B. If these two sets of invariants are not identical, respectively, A is not equivalent to B.

For example, in ordinary translational geometry, two lines

$$ax+by+c=0, \tag{1}$$

and

$$dx+ey+f=0, \tag{2}$$

are equivalent in the sense of being parallel if, and only if, the ratio a/b is equal to the ratio d/e. These ratios are invariants of the lines (1) and (2), respectively, for a translational geometry.

Ordinary plane similarity geometry. The geometry of similar figures is a geometry quite distinct from ordinary Euclidean geometry. In this geometry the relation of similarity is easily shown to satisfy all four properties of an equivalence relation.

Other geometries. There are many other geometries, and the relationships of congruence used in them are examples of equivalence relations. Familiar examples of these types of geometries are projective, non-Euclidean, affine, and the like.

9. *Example from transportation.*—In order to show how these equivalence problems come up in practical fields outside of mathematical subjects, an example may be noted in the field of railroading. In the transportation literature many types of equivalence are commonly used. An example of current discussion in the transportation literature[4] is that of locomotive ratings, "equivalent locomotives." A number of methods of rating locomotives are commonly used, and much general confusion exists as the result of careless use of various types of equivalence relations.

Under present conventional systems of rating, a steam, a Diesel, and an electric locomotive, each locomotive rated as having "a 6,000 h.p. output," are actually only equivalent in the sense that the number 6,000 used happens to be the same, since the method of calculating the horsepower number is totally different in each case (one is cylinder output; the second is Diesel-engine output; the third is continu-

[4] WYNNE, F. E., *Comparable locomotive ratings*, Railway Age **120** (6): 316–318. Feb. 9, 1946.

ous output at rails; and each of them requires careful definitions).

If three locomotives are equivalent in the sense that they can each deliver the same useful output to the rail, they are not necessarily equivalent in the sense of their ability to handle the same weight of cars at 100 m.p.h. on level tangent track. And, if three locomotives are equivalent in this latter sense, they are not necessarily equivalent in the sense that they can deliver the same useful horsepower *continuously* at the rails; nor are they necessarily equivalent in the sense of their earning power, availability, reliability, etc.

Actually under present conventional systems of ratings, three locomotives having an advertised 6,000 h.p. output, one steam, one Diesel, one electric, while equivalent in the sense that the number of 6,000 is the same for all, are not equivalent in the sense of the weight of cars that they can handle at 100 m.p.h. on level tangent track continuously, the values actually being about 1,000 tons, 900 tons, 1,300 tons, respectively. Nor are they necessarily equivalent in their cost per ton mile hauled, availability ratio, etc. Furthermore, there are many other equivalence relations used in rating locomotives, all different, and many times badly misunderstood because of the lack, or omission, of good definitions. A general practical definition of "equivalent locomotives" has never been adequately given; and any such definition would doubtlessly involve the listing of many categories of equivalence and a scheme, or a set of schemes, for weighting these equivalences. A similar situation exists in many other fields.

10. *Equivalence in the elementary theory of sets.*—In the elementary theory of sets, one of the basic notions is that of equivalence. If the elements in two sets, A and B, can be paired with each other in such a manner that to each element of A there corresponds one and only one element of B, and to each element of B there corresponds one and only one element of A, then the correspondence is said to be *bi-unique*, and A and B are said to be *equivalent*.

Two finite sets have the *same number* of elements if and only if the elements of the two sets can be put into bi-unique correspondence. This is the idea of counting, for when one counts a finite set of objects one simply establishes a bi-unique correspondence between these objects and a set of number symbols $1, 2, 3, \ldots, n$. Thus, the notion of equivalence for finite sets corresponds to the ordinary notion of equality of numbers.

The concept of equivalence has been extended to infinite sets. This was done to construct an arithmetic of infinities. In this sort of theory there are just as many points on a straight line as there are real numbers. This means that the set of all real numbers and the set of all the points on a straight line are equivalent in the sense that, once an origin and a unit are chosen, a bi-unique correspondence between the real numbers and the points on the line can be made. With this understanding of equivalence, a finite set cannot be equivalent to any one of its proper subsets, for if the finite set contains n elements and no more, any one of its proper subsets can contain at most $n-1$ elements.

If a set contains infinitely many objects, it may be equivalent to a proper subset of itself. For example, there are just as many positive integers as there are positive even integers. This is easy to see from the bi-unique correspondence shown below.

$$\begin{array}{cccccccc} 1 & 2 & 3 & 4 & 5 & \cdots & n & \cdots \\ \updownarrow & \updownarrow & \updownarrow & \updownarrow & \updownarrow & & \updownarrow & \\ 2 & 4 & 6 & 8 & 10 & \cdots & 2n & \cdots \end{array}$$

In fact, there are just as many rational fractions as there are integers. However, the set of all real numbers is not equivalent to the set of integers.

For those who wish to pursue this sort of equivalence theory, much can be found concerning the subject in the theory of sets (begun by George Cantor at the end of the nineteenth century).

11. *Algebra.*—Algebra furnishes many illustrations of the appropriateness of the concept of equivalence. Thus, if real positive numbers are assumed to be properly defined, then it is possible to introduce negative numbers in quite a logical manner by means of a certain definition for the equivalence of pairs of real positive num-

bers. Such a treatment may be found in the literature[5] and gives quite satisfactory answers to such questions as: Why does $(-1)(-1)=1$? A similar treatment based on the equality of pairs of real numbers can be formulated to give a logical introduction to complex numbers.

12. *Klein's definition of a geometry. Groups.*—In order to illustrate the connection between the theory of groups and the theory of equivalence further examples from geometry may be considered. Felix Klein (1871) defined geometry as the study of the invariants of a group of transformations. A *group* of transformations is a set such that:

1. The resultant transformation of two transformations is a transformation of the set.
2. The associative law holds.
3. There exists an identity transformation.
4. Every transformation has an inverse.

In ordinary Euclidean geometry, the transformations (of rotations and translations) form a group. Likewise in similarity geometry, the similarity transformations form a group. Thus, the geometry of congruent figures and the geometry of similar figures are examples of geometries as defined above.

13. *The resemblance between the definition of group and the definition of equivalence.*—This resemblance is a fundamental one. In associating an equivalence relation with a set of transformations, one associates with a set A of elements the set T of transformations which operates on A transforming it into some set B of elements. One might make a definition of equivalence by saying that B is equivalent to A if there exists a tranformation in the set T which transforms A into B, provided of course that the four properties of an equivalence relation are met. That this can be done, *if* and *only if* the transformations T form a group, can be shown readily.

It can be shown quite easily that:

THEOREM. *Equivalence relative to a group of transformations is an equivalence relation (satisfying properties I, II, III, IV).*

Something of what this theorem means may be illustrated by the following example:

[5] See C. C. MacDuffee, *loc. cit.*

Example. Consider the set of all real rotations T of the points in a plane about a fixed point O. This group may be represented by the equation

$$\text{(T)} \qquad w = ze^{i\theta}. \qquad (i^2 = -1).$$

By this formula any point z in the plane having polar coordinates ρ and α is rotated about the point O into a point w in the plane having polar coordinates ρ and $(\alpha+\theta)$.

That the set (T) of rotations form a group can be seen readily since:

1. The resultant of two rotations θ_1 and θ_2 is a rotation $\theta=\theta_1+\theta_2$ of the set (T).
2. The associative relation holds since for successive rotations, θ_1, θ_2, θ_3, $\theta_1+(\theta_2+\theta_3) = (\theta_1+\theta_2)+\theta_3$.
3. The rotation $\theta=0$ is the identity transformation.
4. Every rotation θ has the inverse rotation $(-\theta)$.

All points P in the plane at a fixed distance ρ from the point O could then be defined as equivalent with respect to the group of rotations (T) in the sense that any one point A of the points P can be transformed into any other point B of the set P by an appropriate rotation θ.

Thus, in this sense, all points on a circle with radius ρ and center O are equivalent to each other. But points on this circle are *not* equivalent to points on a circle with center at O and radius r where $r \neq \rho$. However, all points on the second circle are equivalent to each other in the sense defined.

That *this definition satisfies the four properties for an equivalence relation* follows since:

(A) Either two points in the plane fall on the same circle with center at O, or they do not. Thus property (I) is satisfied.

(B) Two coincident points lie on the same circle with center at O; hence property (II) is satisfied.

(C) When one point is equivalent to a second point they fall on the same circle with center at O; hence the second point is equivalent to the first point. Thus property (III) holds.

(D) When a point A is equivalent to a point B, they lie on a circle with center at O, and if B is equivalent to C they lie on a circle with center at O; hence A and C lie on the same circle since B lies on both circles with center at O. Thus property (IV) holds.

This example serves to illustrate the resemblance between the definitions of group and equivalence.

14. *Isomorphic systems.*—Another mathematical concept of considerable importance in its own right as well as in its applications is that known as *isomorphic systems.*

Consider two systems A and B each consisting of a set of elements and a set of

operations on these elements. Suppose that each system is closed with respect to a given system of operations in the system. The two systems A and B are said to be *isomorphic* or *abstractly identical* with respect to these operations if there exists a biunique one-to-one correspondence between the elements of A and B, such that any formal combination of, or operation on, the elements in A corresponds to the analogous construction with the corresponding elements in B.

In mathematics (such as in algebra) two isomorphic systems are commonly considered as equivalent; and the subject matter of mathematics, in this sense, may be considered as dealing with those properties of systems which are invariant (remain unchanged) for isomorphic systems.

15. *Applications to physical phenomena.*—In any specific situation the elements $a, b, c \ldots$ of a system S are identified with specific physical objects, numbers, quantities, entities, or the like, and the definitions of equivalence used must be carefully given in terms of these elements and the physical systems to which they belong. Each definition of equivalence used constitutes a separation of the set of elements $a, b, c, \ldots$ and associated physical phenomena or systems into classes. This separation into classes is often of considerable physical significance, each type of equivalence often having associated with it an extensive physical theory.

16. *Examples from circuit theory.*—As in mathematical theories, so in physical theories, many non-isomorphic types of equality have been and can be defined, each type of equality often having associated with it an extensive theory. Thus, in the theory of equivalent linear electrical circuits, two 2-pole networks may be equivalent[6] in the sense that for all frequencies they have identical driving-point admittances (or more generally, for $2N$-pole networks, that they have identical characteristic coefficient admittance matrices), *yet* they may not be equivalent in the sense that they have the same number of independent mesh circuits; or, are structurally the same; or, are equally economical to operate; or, are both readily physically realizable; and that if A and B respectively, are their network matrices, A and B may or may not be equivalent in the sense of matric congruence, . . .

Again in the theory of *symmetric components* as used in electrical engineering, the equivalence relationship used may often involve that of *matric similarity* between the matrices used to represent certain characteristics of the network in the various reference systems used in the theory. In this sort of equivalence the actual values of the voltages, currents, and impedances are left undisturbed, though the values of their representations in the various reference systems may be greatly different. Here the equivalence relation known as *matric similarity* is distinctly different from the equivalence relation known as *matric congruence.* Yet, both of these types of equivalence happen to be examples of another type of equivalence known as ordinary *matric equivalence.*

17. *Isomorphism as used in model studies. Principles of similitude.*—In the design of structures, bridges, ships, dams, flood control projects, and the like, the engineer, naval architect, and others responsible for the design must make accurate predictions as to the characteristics, cost, and performance of the various proposed designs. In such work the designers and planners can ill afford to make errors. Such projects are too expensive. Perhaps only one can ever be constructed. The final product must be right. It must do what it is designed to do, reliably, safely, and economically.

Engineers and scientists, in such instances, frequently take recourse to the construction and testing of models of the proposed structure. The results of the tests of the models are then used to predict the performance and characteristics of the proposed prototype. In order that a model test be of real use in predicting the properties of the prototype, great care must be exercised

[6] BURINGTON, RICHARD S., *Matrices in electric circuit theory*, Journ. Math. and Phys. **14** (4): 325–349. Dec. 1935; *A matric theory development of the Theory of Symmetric Components*, Philos. Mag. (ser. 7) **27**: 605. May 1939; *On circavariant matrices and circa-equivalent networks*, Trans. Amer. Math. Soc. **48** (3): 377–390. Nov. 1940.

in its design. Furthermore, considerable care is necessary in interpreting the measured and computed properties of the model test in terms of the prototype.

Theoretically, in designing a model test and in constructing the models for the test, every physical parameter of importance in the prototype must be considered and taken into account. It is not sufficient merely to make the dimensions of the model and prototype proportional. If a theory of similitude is not available, then one must be developed. Such a theory must serve as the basis for designing and constructing the model from its prototype dimensions. It must serve also as the guiding principle in interpreting the measurements made on the model in terms of the corresponding measurements as predicted for the prototype. If this theory of similitude is a perfect one, and the application of this theory is also perfect, then there is a one-to-one bi-unique correspondence between the various physical parameters of the prototype and the corresponding ones of the model; and every operation on or with the prototype has a corresponding operation on the model. In other words, any characteristic of the model as predicted through the isomorphism thus stated must be a true characteristic of the prototype, and vice versa. (This is an example of the equivalence property, if $A \underline{\underline{E}} B$, then $B \underline{\underline{E}} A$.)

In practice it is impossible to apply perfectly such a theory and expect the results predicted through the model test to be completely true for the prototype. A measure of this perfection lies in a comparison of the actual characteristics of the prototype with those predicted by the model studies. Consequently the aim in all such work is the construction of as near perfect an equivalent system of models as is humanly possible. In other words, these models must be as nearly isomorphic with their corresponding prototypes as possible.

An example where consideration is given to many physical parameters of importance may be found in hydrodynamics. In hydrodynamic studies, lengths L, a, b, c, . . . , time T, velocity V, mass M, force F, pressure increment p, mass density ρ, specific weight γ, viscosity μ, surface tension σ, and elastic modulus e for the object and fluid must be considered. (For convenience, L, M, F may be taken as the three fundamental dimensions.)

A number of theories of similitude have been developed for use in aero- and hydrodynamics. In one such theory, widely used, there is defined a certain set of dimensionless numbers

$$\pi_1=\frac{a}{b}, \quad \ldots, \quad \pi_4=\frac{\rho V^2}{p}, \quad \pi_5=\frac{V^2/a}{\gamma/\rho},$$

$$\pi_6=\frac{Va}{\mu/\rho}, \quad \pi_7=\frac{V^2a}{\sigma/\rho}, \quad \pi_8=\frac{V^2}{e/\rho}, \quad \ldots,$$

which must be kept unchanged if true similarity (i.e., isomorphism) is to exist between the flow about the prototype and the flow about the model. In other words, if true similarity is to exist, every dimensionless parameter π_n, referring to conditions in the model, must have the same numerical value as the corresponding parameter for the prototype. This means, for one thing, that the model and prototype must be completely similar geometrically. To put the problem in another way, the set of dimensionless numbers π_1, . . . for the prototype must be identical with the corresponding set π_1, . . . for the model—if true similarity between prototype and model exists, and if predictions made from model studies are to be valid for the actual prototype. A mathematician would say that the parameters π_1 . . . , must be absolute invariants for the prototype and model systems. Because the quantities π_1, . . . , π_n, . . . are invariant for these isomorphic systems, the model and prototype systems are said to be equivalent.

Thus, if $\pi_1=a/b$ is to be invariant, where a and b are any two linear dimensions of the prototype, the corresponding linear dimensions a' and b' of the model must be so related that $\pi_1=a'/b'$. The reader can, for himself, discover other requirements on the model by merely holding each of the other parameters π_2, . . . fixed and interpreting the quantities in these parameters first, in terms of the prototype, and secondly, in terms of the model.

From a practical standpoint it is usually

impossible to realize fluids and values of the physical parameters of these fluids to satisfy *all* the requirements implied when the absolute invariance of the set $\pi_1, \ldots$ is demanded. This means that it is impossible to obtain a true model on any but the same scale using any but the same fluid as prototype. Of course, in this case, the model and the prototype would be equivalent. (This is an example of the equivalence property $A \mathrel{\underline{\underline{E}}} A$.) In spite of the difficulty and the knowledge that any practical model system cannot be made perfectly isomorphic with its prototype, much can be learned and reasonably reliable predictions can be obtained from such model studies.

In the testing of ship models and partly submerged objects, such as buoys and seaplanes, it has been found possible to make rather good predictions as to the behavior of the prototype by designing the model studies so as to keep the Froude number π_5 invariant. This compromise places the emphasis on the dominant physical parameters involved, namely, inertia and gravity forces, since π_5 is their ratio. In such work, π_4 known as Newton's number, can also be kept invariant. As a rule it is not possible to keep the remaining functions $\pi_2, \pi_3, \pi_6, \ldots$ invariant. This compromise means that the model system will be equivalent to the prototype system in the sense that the Froude and Newton's numbers are identical, respectively, for both the prototype and the model; but it does not mean that the prototype system and the model system are completely isomorphic otherwise.

When other physical parameters different from mass and inertia are considered to be of greater importance, then some other dimensionless numbers become of prime interest, and the functions π_i, π_j, corresponding to the two most important physical parameters are made absolutely invariant. Thus, in aerodynamics, emphasis is often placed on Reynold's number, π_6, rather than the Froude number π_5, since skin friction (viscosity) is then of prime importance. π_6 is the ratio of inertia and viscous forces.

Where inertia force and compressibility predominate, emphasis is placed on the Mach number, π_8, which is the ratio of the velocity of flow to the velocity of sound in the fluid at the given temperature.

18. *The use of equivalence principles in the design and testing of equipment.*—Aircraft, railway cars, and the like must be able to withstand great stresses and strains and much rough handling and must not be too vulnerable to damage from a great variety of causes. In designing such equipment a great deal of attention must be given to strength, safety, reliability, and costs, while recognizing economical and utilitarian values. Such considerations commonly involve various types of testing procedures designed to indicate the strength, reliability, etc, of vital portions of the equipment, as well as of the structure as a whole. Thus, the wings of an airplane or the axles of a truck can be tested in various ways for strength, ability to withstand shock, etc; the vulnerability of the fuselage or body to fire can be studied; and so on. But the results of such studies are only a partial indication of the strength and vulnerability of the airplane or car as a whole. Consequently, when possible, tests of the equipment as a whole are sometimes set up and the results obtained compared with the results of the tests of specific parts of the equipment. Of course, the ultimate test lies in the experience gained with the equipment under actual service conditions for a long period of time under a great variety of circumstances.

The quantities involved in criteria developed for use in testing may be quite different from the quantities available from over-all testing or from operational experience. An adequate theory for correlating (a theory of equivalence) these measures obtained in tests of specific parts and in over-all testing and experience must be formulated. Thus in attempting to measure, say, the ability of a car to withstand collision, controlled tests might be made in the laboratory, in which such parameters as energy, velocity, deformation, stress distribution, bending moments, momentum, pressure, and the like are used. Yet such parameters as these may not be available in examining the damage to such a car in collision; the only real information available being that which can be observed and de-

duced from the wreckage. The need for a theory for correlation (equivalence) is evident in such a case.

To summarize in connection with such test results there appears:

(*1*) The problem of the formulation of criteria and methods for describing, defining, and measuring such things as strength, safety, vulnerability to damage, . . . of the component parts of the equipment, as well as of the equipment as a whole.

(*2*) The problem of formulating principles for correlating these measures of strength, safety, damage, ... These measures may be observed in experiments—
- (*a*) with specific parts of the equipment,
- (*b*) with specific assemblies of the equipment,
- (*c*) with the equipment as a whole under test conditions,
- (*d*) with the equipment as used in actual operations.

In order that an adequate basis for reliably predicting the worth and safety of a design be realized, each of these major problems must be faced and an adequate solution obtained when at all possible. The construction of such a theory and mode of prediction, if it is to be a good one, must involve a careful use of the principles of equivalence. The importance of this procedure is all the more important since actual operational experience with a new design of certain types of equipment may be, costly (or even dangerous to human life) and such experience cannot always be made available before production.

Thus, in the field of design, testing, etc., there is a continuing need for the wise use of the principles of equivalence.

19. *Recent mathematical developments*[7].—In recent years much progress has been made by such mathematicians as Ore, MacDuffee, Garrett Birkhoff, and others in extending the analysis of the theory of equivalence relations. These extensions have served to connect rather diverse mathematical fields and have gone deeply into various fields of abstract algebra, topology, and related fields and apparently are leading to still a more general and abstract theory of mathematical relations. These investigations are of interest chiefly to workers in certain branches of pure mathematics. To what extent some of these abstractions will be of immediate value to workers in the applied fields remains to be seen. But this much seems clear, that: Consciousness of the concept of equivalence as outlined herein is of real value in many physical fields. It helps to clarify many problems. It provides a means of attack. It should be remarked, however, that the involved details in the development of the modern theory of equivalence relations will in themselves be of little value in practical and scientific problems unless a penetrating inquiry into the economic, physical, or other pertinent background of the problem at hand is made. This last point is of great importance.

To illustrate what is meant, consider the following well known mathematical results:

A *partition* P of the set S is a decomposition of S into subsets $C_1, \cdots, C_n, \cdots$ such that every element in S belongs to one and only one set C_n. The sets C_n are called *blocks* of the partition P, and $P=P(C_n)$ is written to indicate this.

THEOREM. *Any partition $P(C_n)$ defines an equivalence relation E in the set S when one puts $A \underline{\underline{E}} B$ whenever A and B belong to the same block C_n. Conversely, any equivalence relation E defines a partition $P(C_n)$ where the block C_n consists of all elements equivalent to any given element A.*

This theorem tells us that there are many possible equivalence relations definable for a set S. Which particular equivalence relations are worth studying seriously will depend on the set itself and what general problems are under consideration. Thus, if S is the set of all locomotives, many types of equivalance relations can be defined, such as equivalence in the sense of the same cylinder output; or continuous output at the rails; or equivalence in the sense that they have, or do not have, brass trimming around the edge of the headlight; or equivalence in the sense that they can reach a maximum speed of 100 miles per hour, or not; or equivalence in the sense that the locomo-

[7] WHITMAN, P. M., *Lattices, equivalence relations and subgroups*, Bull. Amer. Math. Soc. **52** (6): 507–522. June 1946; ORE, OYSTEIN, *Theory of equivalence relations*, Duke Math. Journ. **9** (3). Sept. 1942; BIRKHOFF, GARRETT, *On the structure of abstract algebras*, Proc. Cambridge Philos. Soc. **31**: 433–454. 1935; MACDUFFEE, C. C., *loc. cit.*

tives are named after some one, or are not; etc. Now obviously, some of these types of equivalence have some reason for existence, while others are of course trivial or ridiculous. To repeat the point: Involved details in the theory of equivalence relations will in themselves be of little value in practical problems unless a penetrating inquiry into the economic, physical, or other pertinent background of the problem at hand is made.

20. *Summary.*—The present paper discusses some of the meanings that may be attached to the phrase "A is equivalent to B." A glimpse of the mathematical properties that must be possessed by an equivalence relation has been shown. Isolated examples of equivalences in geometry, set theory, number theory, algebra, electrical networks, hydrodynamics, and engineering have been cited. Some attention has been given to the theories of modeling and similitude, which are so important in hydro- and aerodynamics, theories in which a form of equivalence known as *isomorphism* plays a leading role.

The use of either perfect or approximate isomorphic systems (or more general equivalent systems) appears as a fundamental process in almost all studies of physical phenomena. The method consists broadly of:

(1) The extraction from the physical phenomena S of a nearly isomorphic (equivalent) physical model P.
(2) Reduction of the physical model P to an isomorphic (equivalent) mathematical model M amenable to treatment.
(3) A solution of this mathematical system M.
(4) The interpretation of the solution found in (3) in terms of the mathematical model M.
(5) The interpretation of the solution found in (4) in the physical model P.
(6) Finally, the interpretation of the result (5) in the original physical settings.

Although at present it is not clear how much value the abstract extensions of the theory of equivalence relations will prove to be for use in the applied fields, it does appear that the theory will be beneficial in offering a background for the broad approaches to practical problems.

BOTANY.—*Studies in* Lonchocarpus *and related genera, II: Miscellaneous Middle American Lonchocarpi.*[1] FREDERICK J. HERMANN, U. S. Department of Agriculture.

The most extensive and generally useful of the comparatively recent partial treatments of the genus *Lonchocarpus* is Henri Pittier's *The Middle American species of Lonchocarpus* (Contr. U. S. Nat. Herb. **20:** 37-93. 1917). This monographic account embraces the 40 species known from Mexico and Central America 30 years ago, to which are appended a list of six excluded or doubtful species and detailed descriptions of nine related South American and West Indian Lonchocarpi. One of the first tasks of a current review of the genus as a whole is, therefore, to attempt to allocate within the framework of the classification proposed by the author of that work the miscellaneous species subsequently described by various other authors from the same area. In some cases the systematic position of a recently proposed species has been correctly indicated by its author and characteristics distinguishing it from its nearest allies may have been pointed out; in others lack of either flowering or fruiting material may have prevented this; in still others a misinterpretation, due either to faulty earlier descriptions or to the author's lack of comprehensive familiarity with the group, may vitiate the supposed relationship and hence sectional position or taxonomic status; and, finally, in some instances no attempt whatever has been made to indicate the relationship of the new species.

No discussion seems to be required here of such of these species as have been satisfactorily disposed of by other authors, such as *Lonchocarpus caribaeus* Urban (referred to the synonymy of *L. benthamianus* Pittier by Harms in Fedde Rep. Spec. Nov. **17:** 323. 1924), *L. capensis* M. E. Jones (shown to be actually *Tamarindus indica* L. by Morton in Contr. U. S. Nat. Herb. **29:** 103. 1945), *L. modestus* Standl. & Steyerm. (transferred to *Lennea* by its authors in

[1] Received July 8, 1947.

Fieldiana, Botany, **24** (5): 275. 1946), and *L. trifoliolatus* Standl. (equated with *L. phaseolifolius* Benth. by Standley and Steyermark in Fieldiana, Botany, **24** (5): 282. 1946). Six additional names (*L. argyrotrichus* Harms, *L. calderoni* Standl., *L. lindsayi* Standl., *L. obovatus* Benth., *L. salvinii* Harms, and *L. schiedeanus* (Schlecht.) Harms) have been recently transferred to *Willardia* by the writer (Journ. Washington Acad. Sci. **37**: 427. 1947), to which genus Standley (Contr. U. S. Nat. Herb. **23**: 483. 1922) had already referred *L. eriophyllus* Benth.

It seems desirable to present the conclusions of the writer upon the following additional eight species, particularly since certain original misinterpretations are being perpetuated in recent important floristic works such as the *Flora of Guatemala*.

Lonchocarpus amarus Standl., Carnegie Inst. Washington Publ. 461: 63. 1935 = VATAIREA LUNDELLII (Standl.) Killip *ex* Record (*Tipuana lundellii* Standl. l.c. 65).

Since the original material of *Tipuana lundellii* lacked flowers and that of *Lonchocarpus amarus* is without fruit, the failure to realize the identity of the two is readily understandable. The alternate leaflets, diadelphous stamens, wings of the corolla free from the keel, and the strikingly funnelform calyx of *Lonchocarpus amarus* definitely exclude it from that genus. Flowering specimens of *Vatairea lundellii* (collected since the publication of that species), kindly lent to the writer for study by the Chicago Natural History Museum, are identical with the type of *L. amarus*. *Vatairea lundellii* appears to be most nearly related to the Amazonian *V. fusca* Ducke, from which it is distinguishable by the appressed rather than spreading pubescence of the calyx, pedicels, and peduncles, by its broader wing petals (4.5 mm), by having the stamens definitely shorter than the pistil, and by the tendency of the calyx to split in the late-bud stage, between the vexillar teeth.

Lonchocarpus dumetorum Brandegee, Univ. California Publ. Bot. **10**: 181. 1922 = L. DARIENSIS Pittier, Contr. U. S. Nat. Herb. **20**: 69. 1917.

The type specimen of *L. dumetorum* (*Purpus 8591;* this and other Brandegee types reviewed through the courtesy of the University of California Herbarium) is a good match with that of *L. dariensis* (*Pittier 5515*, U. S. National Herbarium). It has, in addition to flowers and leaves, nearly mature legumes, which are very closely similar to those of *L. megalanthus* Pittier, this similarity bearing out Dr. Pittier's tentative alignment of it, in the absence of fruit, with the latter species. Both *L. dariensis* and *L. megalanthus*, however, as well as the closely related *L. mexicanus* Pittier, have leaflets conspicuously punctate, and so they could not be keyed out to his section Epunctati wherein he placed them. It seems probable that this is what led Brandegee to believe that he had an undescribed species in his *L. dumetorum*, and the same discrepancy may have been partly responsible for his proposal of *L. purpusii*.

Lonchocarpus izabalanus Blake, Contr. U. S. Nat. Herb. **24**: 7. 1922 = L. LUTEOMACULATUS Pittier, Contr. U. S. Nat. Herb. **20**: 64. 1917.

Lonchocarpus luteomaculatus is a highly variable species, almost as polymorphic in fact as its near ally *L. latifolius* (Willd.) HBK. The type of *L. izabalanus* is very similar to many recent collections of *L. luteomaculatus*. It was differentiated, in the original description, principally by the possession of a maroon banner with a green spot at the base instead of a purple banner with a basal yellow spot, but it seems likely that the flower color ascribed to *L. luteomaculatus* by its author was that of the dried plant and that in the fresh state it may be actually closer to the maroon-green pattern. At any rate, there now seems to be no distinguishable difference between the corolla colors of the two type specimens (*Blake 7841* and *Pittier 4170*, U. S. Nat. Herb.).

Lonchocarpus kerberi Harms, Fedde Rep. Spec. Nov. **17**: 322. 1921 = L. PENINSULARIS (Donn. Smith) Pittier, Contr. U. S. Nat. Herb. **20**: 56. 1917.

A fragment of the type of *L. kerberi* (*Kerber 35*) is fortunately preserved in the herbarium of the Chicago Natural History Museum. This is sufficiently ample to show that it is not at all related to *L. benthamianus* Pittier, *L. proteranthus* Pittier, and *L. punctatus* HBK., as supposed by Harms, and that it differs from the type of *L. peninsularis* (*Tonduz* s.n. (***Inst.***

Fís. Geogr. Costa Rica 13961), U. S. Nat. Herb.) only in the corolla being slightly less pubescent. It is not surprising that *L. kerberi* was regarded as a new species by its author and that its affinities were misinterpreted. Since it has leaflets that are not impressed-nerved and that are unmistakably punctate, its relationship with *L. peninsularis* would scarcely be suspected in view of the fact that the latter is placed by Pittier in his series Impressinervi and that his description includes no reference to the conspicuously punctate character of the leaflets mentioned by Donnell Smith in his original description of the species as *Derris peninsularis* (Bot. Gaz. **44**: 111. 1907). Actually, *Lonchocarpus peninsularis* and the likewise misplaced *L. nicoyensis* (Donn. Smith) Pittier and *L. costaricensis* (Donn. Smith) Pittier belong to the series Planinervi. Both *L. peninsularis* and *L. nicoyensis* fall into the section Punctati, the former being apparently most closely related to *L. longistylis* Pittier. It is doubtless due to the anomalous position in Pittier's classification of the frequently collected *L. peninsularis* that still another synonym of this species was created—*L. purpusii* Brandegee.

Lonchocarpus monospermus Standl., Field Mus. Publ. Bot. **4**: 311. 1929 = L. LUTEOMACULATUS Pittier, Contr. U. S. Nat. Herb. **20**: 64. 1917.

The distinguishing feature ("small one-seeded pods") attributed to *L. monospermus* is quite prevalent in *L. luteomaculatus*, the pods of the type specimen of *L. luteomaculatus* (*Pittier 4170*, U. S. Nat. Herb.) being predominently 1-seeded and 2.5 cm long. The type of *L. monospermus* (*Standley 53715*, Chicago Nat. Hist. Mus.) appears to differ in no tangible respect from this.

Lonchocarpus purpusii Brandegee, Univ. California Publ. Bot. **6**: 500. 1919 = L. PENINSULARIS (Donn. Smith) Pittier, Contr. U. S. Nat. Herb. **20**: 56. 1917.

The type specimen of *L. purpusii* (*Purpus 7849*, Univ. Calif.) is a very close match with that of *Derris peninsularis* in the U. S. National Herbarium. For discussion see *L. dumetorum* and *L. kerberi* above.

Lonchocarpus seleri Harms, Fedde Rep. Spec. Nov. **17**: 324. 1921 = L. HONDURENSIS Benth., Journ. Linn. Soc. **4**: Suppl. 91. 1860.

L. seleri was set off from *L. hondurensis* by Harms "durch fast sitzende Blüten auf längerem gemeinsamen Stiele und wohl auch grössere Vorblätten." Examination of a large series of *L. hondurensis*, however, shows the relative length of peduncle and pedicel to be very unstable; for example, *Mell 530* (U. S.) is *L. seleri* in its peduncles but not in its pedicels whereas *Wilson 706* (U. S.) is *L. seleri* in its pedicels but not in its peduncles. No difference was found between the bracts in the type fragment of *L. seleri* in the Chicago Natural History Museum (*Seler 5052*) and those of *L. hondurensis*, which are exceedingly variable.

Lonchocarpus xuul Lundell, Bull. Torrey Bot. Club **69**: 391. 1942.

The reference of this species to the synonymy of *L. guatemalensis* Benth. in the recently published *Flora of Guatemala* (Fieldiana, Botany, **24**(5): 278–279. 1946) seems to be clearly erroneous. The long stipes (averaging 1 cm) of the short, thick pods (generally 2.5–4 cm long) of *L. xuul* and its much smaller flowers set it off at a glance from *L. guatemalensis* with its sessile or subsessile, long, flat legumes (averaging 6–20 cm long). The author of *L. xuul* correctly indicated its close relationship with *L. constrictus* Pittier among the Middle American species. Its nearest ally in the genus as a whole is the Venezuelan *L. mirandinus* Pittier, with which it shows a striking similarity in its fruit but from which it differs in its few (5 to 9 rather than averaging 15), blunt leaflets and in its mainly green flowers.

The disposition of the following 17 binomials, the remainder of those proposed from Middle America since 1917, must be postponed either because no specimens have yet been procurable for study or because the material so far available has not been sufficient for more than tentative conclusions:

L. apricus Lundell, Lloydia **2**: 90. 1939. Chiapas, Mexico.
L. belizensis Lundell, Wrightia **1**: 55. British Honduras.
L. castilloi Standl., Tropical Woods **32**: 15. 1932. Guatemala; British Honduras.
L. chiapensis Lundell, Wrightia **1**: 152. 1946. Chiapas, Mexico.
L. cruentus Lundell, Wrightia **1**: 55. 1945. Tobasco, Mexico.
L. fuscopurpureus Brandegee, Univ. California Publ. Bot. **10**: 405. 1924. Veracruz, Mexico.

L. galleotianus Harms, Fedde Rep. Spec. Nov. **17:** 322. 1921. Oaxaca, Mexico.
L. gillyi Lundell, Wrightia **1:** 56. 1945. Chiapas, Mexico.
L. hidalgensis Lundell, Wrightia **1:** 153. 1946. Hidalgo, Mexico.
L. hintoni Sandwith, Kew Bull. Misc. Inf. 1936: 4. 1936. Mexico and Guerrero, Mexico.
L. malacotrichus Harms, Fedde Rep. Spec. Nov. **17:** 323. 1921. Mexico.
L. monofoliaris Schery, Ann. Missouri Bot. Gard. **30:** 89. 1943. Panama.
L. nicaraguensis Lundell, Wrightia **1:** 154. 1946 Nicaragua.
L. phlebophyllus Standl. & Steyerm., Field Mus. Publ. Bot. **23** (2): 56. 1944. Guatemala.
L. stenodon Harms, Fedde Rep. Spec. Nov. **17:** 324. 1921. Oaxaca, Mexico.
L. whitei Lundell, Wrightia **1:** 154. 1946. Nicaragua.
L. yoroensis Standl., Field Mus. Publ. Bot. **9** (4): 296. 1940. Honduras.

ZOOLOGY.—*On the crayfishes of the* Limosus *section of the genus* Orconectes (*Decapoda: Astacidae*).[1] HORTON H. HOBBS, JR., Miller School of Biology, University of Virginia. (Communicated by FENNER A. CHACE, JR.)

In the course of working over a series of crayfishes from the Nashville, Tenn., area collected for me by Dr. C. S. Shoup, of Vanderbilt University, and Dr. Mike Wright, of Tusculum College, it was necessary to examine the type specimens of several of the species of the *Limosus* section. In making this study I arrived at certain conclusions, which are discussed below, concerning the affinities of the members of this section which are not in accord with the opinions of others. In addition to the description of a new species I am including a key to the species of the *Limosus* section.

The new species herein described was first reported by Fleming (1939) under the name *Cambarus propinquus sanborni* Faxon. I have compared my specimens with Fleming's description and figures which leave much to be desired. In addition, I have examined several crayfish he sent to the United States National Museum[2] from the only locality he cited for his *C. propinquus sanborni*, and I am convinced that his specimens were members of the species I am describing below. The only locality that Fleming recorded is "Mill creek, located about 4 miles south of Nashville where this creek crosses the Murfreesboro Road [U. S. Hy. 41], studied on August 18, 1935" (Fleming, 1939, **13:** 298).[3]

Genus **Orconectes** Cope 1872

Orconectes shoupi, n. sp.[4]

Cambarus propinkuus Fleming, 1939, **14:** 305 (in part).
Cambarus propinquus sanborni Fleming (not Faxon), 1939, **14:** 305, 306 (in part), 319, 320, and pl. 14.

Diagnosis.—Rostrum with lateral spines, margins thickened and concave laterad; upper surface with or without a median carina. Fingers of chela with usual longitudinal ridges much reduced; whole hand resembling that of *O. rusticus placidus* (Hagen, 1870: 65). Epistome with a median carina (see Fig. 4). Areola approximately 9 to 10 times longer than broad, with two or three punctations in narrowest part—length 34–36 percent of entire length of carapace; in male, hooks on ischiopodites of third pereiopods only. Terminal elements of first pleopod of first-form male short, reaching almost to coxopodite of second pereiopod. Two terminal elements separated for only a short distance near tip: mesial process recurved caudomesiad and shorter than central projection. Annulus ventralis immovable. (See Fig. 5 for surface contour.)

Holotypic male, form I.—Body subovate,

[1] Received July 17, 1947.
[2] These are not the specimens mentioned by Fleming in his report of the higher Crustacea in the Nashville region, for he stated that Mill Creek was "studied on August 18, 1935," and these were collected on August 15, 1936.
[3] This peculiar citation is necessary because Fleming's paper was divided, and appeared in two volumes of the Proceedings of the Tennessee Academy of Sciences; an overlapping in page references causes a further complication. See "Literature Cited."
[4] Dr. C. S. Shoup has made a definite and worth-while contribution toward a knowledge of the fauna of the State of Tennessee. In token of the interest he has shown in my work on the crayfishes and the many specimens he has added to my collection, I name this new species in his honor.

distinctly depressed. Abdomen narrower than thorax. Width of carapace greater than depth in region of caudodorsal margin of cervical groove (15.2–9.4 mm).

Areola moderately narrow (9.6 times longer than broad), with two or three punctations in narrowest part; cephalic section of carapace about 1.8 times as long as areola (length of areola about 35.6 percent of entire length of carapace).

Rostrum with thickened margins concave laterad. Upper surface concave, but bearing a weak median carina. Base of acumen set off by corneous knoblike tubercles directed cephalodorsad. Acumen long and terminating cephalad in a corneous knob similarly disposed as the tubercles at its base. Subrostral ridges prominent and visible in dorsal aspect to base of acumen. Raised lateral margins of rostrum flanked laterally and mesially by rows of prominent setiferous punctations.

Postorbital ridges prominent, grooved dorsad and terminating cephalad in heavy acute tubercles. Suborbital angle absent. Branchiostegal spine obtuse, very much reduced. Small lateral spine present on each side of carapace. Surface of carapace granulate laterally and bearing prominent punctations dorsally; small polished area in gastric region.

Cephalic section of telson with two spines in each caudolateral corner.

Epistome bell-shaped in profile with a median longitudinal ridge; no cephalomedian projection.

Antennules of the usual form, with a small spine present on ventral surface of basal segment.

Antennae broken in holotype but extending caudad to cephalic margin of telson in other specimens. Antennal scale of moderate width with subparallel mesial and lateral margins; outer portion broad and swollen and terminating distad in a heavy spine; lamellar portion broad (see Fig. 9).

Chela somewhat depressed; palm inflated; prominent setiferous punctations present over most of chela. Inner margin of palm with three rows of squamous ciliated tubercles. Fingers widely gaping at base. Upper surface of immovable finger with a narrow well-defined ridge along mesial margin; lateral and lower margins with prominent punctations; upper opposable margin with a row of 18 rounded corneous tubercles; an additional prominent tubercle present below this row at base of distal fifth of finger; minute denticles occurring in a single row on penultimate fifth of mesial surface of immovable finger; mesial distal fifth with a broader zone of similar denticles; lower proximomesial surface bearded. Opposable margin of dactyl with 23 rounded corneous tubercles; distal half of mesial margin bearing minute denticles interspersed between the rounded tubercles. Otherwise dactyl similar to immovable finger.

Carpus of first pereiopod longer than broad, with a prominent longitudinal furrow on upper surface; all surfaces with scattered punctations. Mesial surface with a heavy spinous tubercle; distal upper mesial margin with a prominent rounded tubercle; lower distal margin with two heavy tubercles.

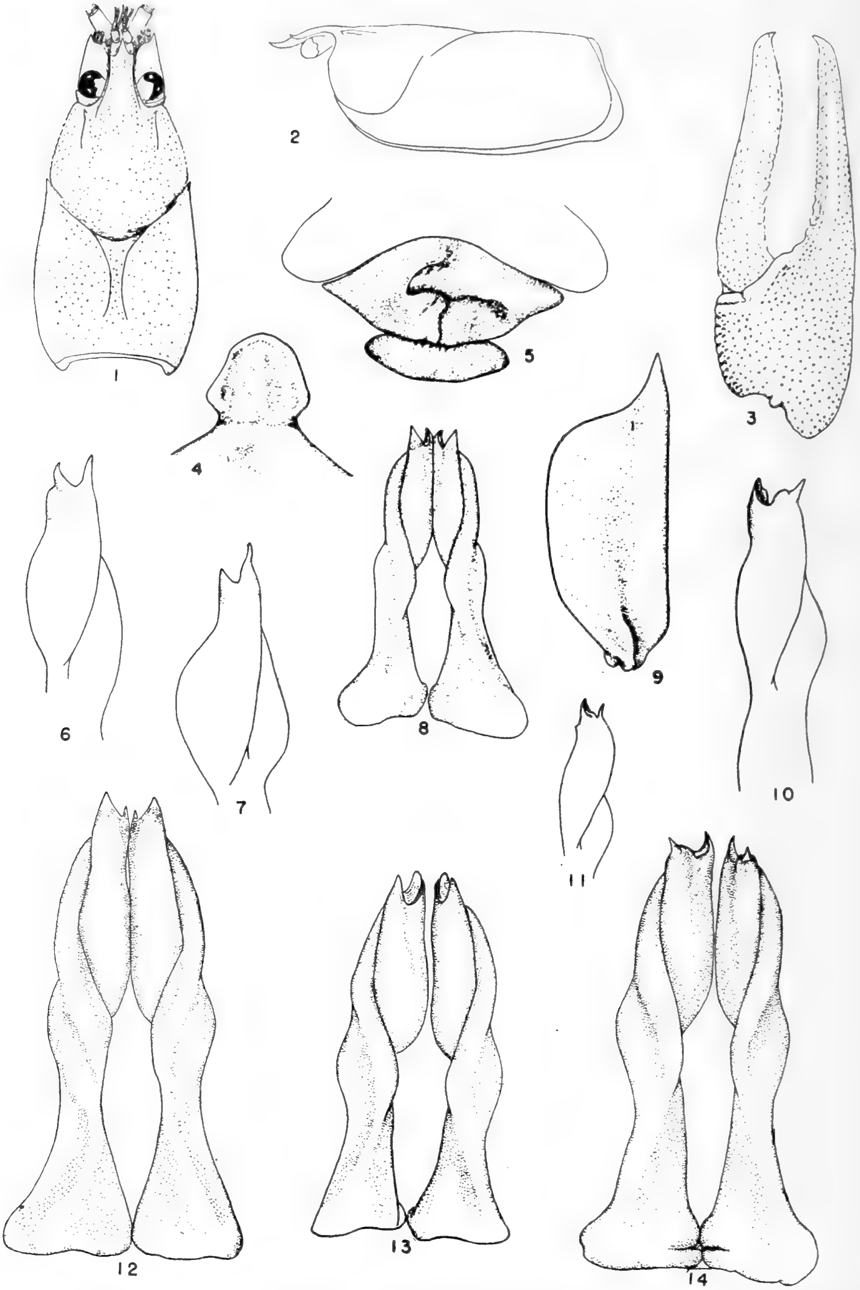
Merus, viewed laterally, with a single prominent tubercle on upper distal surface (a somewhat less prominent one lying mesiad of it but not evident in lateral aspect, nor is it present on sinistral merus). Lateral and mesial surfaces sparsely punctate. Lower surface with a lateral row of five small tubercles and a mesial row of eight (only the distal one in each row at all prominent).

Hooks on ischiopodites of third pereiopods only; hooks strong with proximal surfaces subplane and bearing setae.

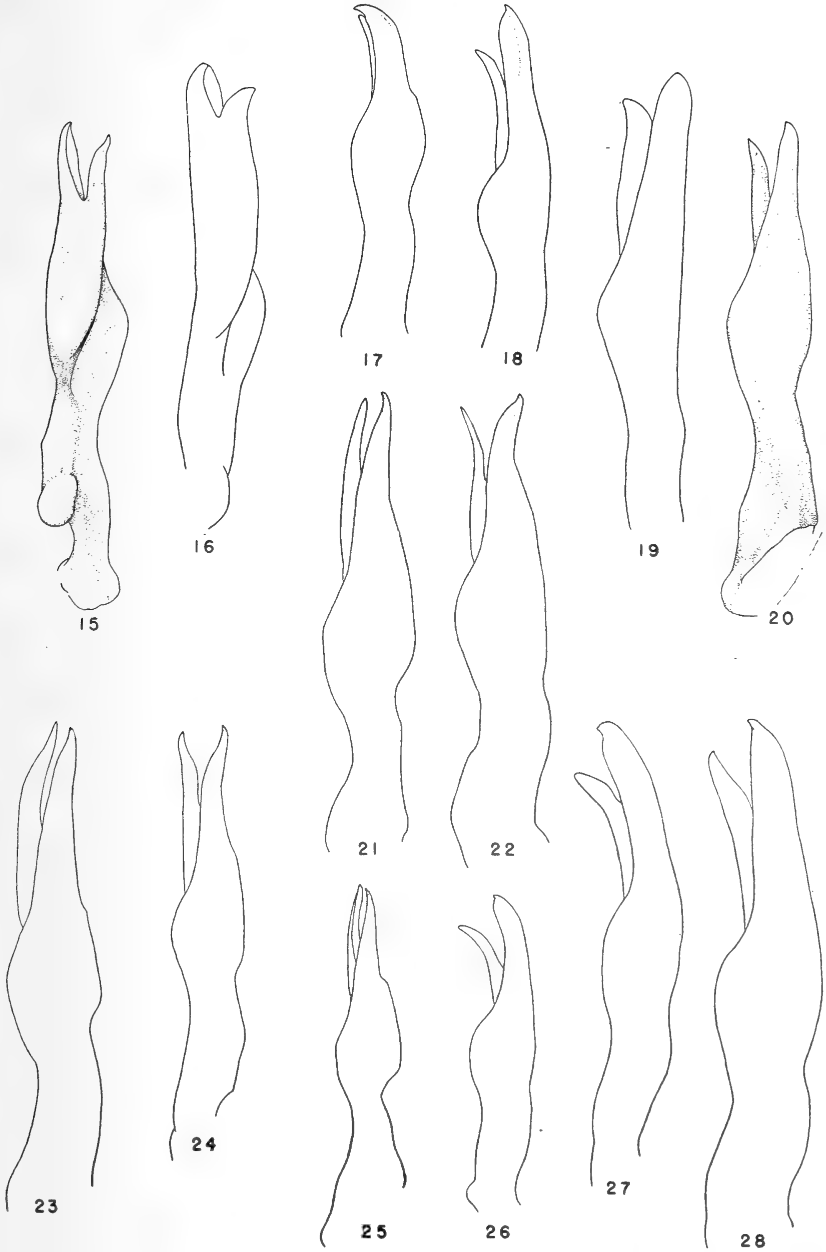
First pleopod almost reaching coxopodite of second pereiopod when abdomen is flexed. Tip terminating in two distinct parts, which are separated for only a short distance. Central projection corneous, almost straight, and somewhat bladelike, with tip slightly recurved. Mesial process extending distad for the proximal half of its length, then bending somewhat sharply caudomesiad.

Morphotypic male, form II.—The only second-form male collected from the type locality is immature. Most of the tubercles mentioned in the description of the first-form male are present in this specimen as acute spines. The lower surface of the carpus and the cephalomesial surface of the merus of the cheliped with tufts of long plumose setae. Rostrum without median carina. Hook on ischiopodite of third pereiopod very much reduced. See Figs. 16 and 19 for structure of first pleopod of a mature second-form male from Mill Creek.

Allotypic female.—Differs from the holo-



FIGS. 1–14.—1, Dorsal view of carapace of *Orconectes shoupi*, n. sp.; 2, lateral view of same; 3, upper surface of chela of first-form male, *O. shoupi;* 4, epistome of *O. shoupi;* 5, annulus ventralis of *O. shoupi;* 6, mesial view of first pleopod of first-form male of *O. pellucidus australis* (Rhoades), from McFarlen Cave, SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 22, T. 3, R. 3 E., near Garth, Jackson County, Ala.; 7, mesial view of first pleopod of first-form male of *O. pellucidus pelluicdus* (Tellkampf), from Mammoth Cave, Roaring River, Edmonson County, Ky.; 8, caudal view of first pleopods of first-form male, *O. pellucidus packardi* Rhoades (holotype), from Cumberland Crystal Cave at Alpine, Pulaski County, Ky.; 9, antennal scale of *O. shoupi;* 10, mesial view of first pleopod of first-form male, of *O. inermis* Cope, from Seibert's Well Cave near Wyandotte Cave, Crawford County, Ind.; 11, mesial view of first pleopod of first-form male of *O. pellucidus packardi* Rhoades (holotype) (see explanation of Fig. 8); 12, caudal view of first pleopods of first-form male of *O. pellucidus pellucidus* (Tellkampf) (see explanation of Fig. 7); 13, caudal view of first pleopods of first-form male of *O. pellucidus australis* (Rhoades) (see explanation of Fig. 6); 14, caudal view of first pleopods of first-form male of *O. inermis* Cope (see explanation of Fig. 10).



FIGS. 15–28 (all figures except 15, 16, and 19 lateral views of the first pleopods of first-form males).—15, Mesial view of first pleopod of first-form male of *Orconectes shoupi*, n. sp.; 16, same, second-form male; 17, *O. harrisoni* (Faxon), from stream at Irondale, Washington County, Mo.; 18, *O. sloani* (Bundy), from Little Creek, Jefferson Township, Preble County, Ohio; 19, lateral view of first pleopod of second-form male of *O. shoupi;* 20, *O. shoupi;* 21, *O. rafinesquei* Rhoades (holotype), from Rough River, at Falls-of-Rough, Grayson-Breckinridge Counties, Ky.; 22, *O. limosus* (Rafinesque), from Leman Place, Lancaster County, Pa.; 23, *O. tricuspis* Rhoades (holotype), from Pete Light's Spring, 3 miles east of Canton, Trigg County, Ky.; 24, *O. indianensis* (Hay), no locality given, U.S.N.M. no. 44448; 25, *O. propinquus propinquus* (Girard), from Rocky Creek, Muncie County, Ill.; 26, *O. difficilis* (Faxon), from stream 1 mile south of Wilburton, Latimer County, Okla.; 27, *O. kentuckiensis* Rhoades (holotype), from Piney Creek, 3 miles west of Shady Grove, Crittenden County, Ky.; 28, *O. sloani* (Bundy), Indiana (probably from near New Albany), U.S.N.M. no. 58058.

typic male in that the tubercles are for the most part more spiniform; epistome with a small cephalomedian spine; upper distal surface of merus of cheliped with two prominent tubercles evident in lateral aspect; extreme distal margin of merus emarginate; lower surface of merus and mesial surface of carpus with tufts of plumose setae. Annulus ventralis subspindle-shaped, with the greatest length in the transverse axis; cephalic margin evenly rounded and firmly fused with sternum; sinus originates near cephalomedian margin, extends caudad for a short distance, and turns gently caudodextrad, then abruptly sinistrad to cross the median line; here it turns caudad and slightly dextrad to the median line and then caudad to the midcaudal margin of the annulus (see Fig. 5).

Measurements.—Holotypic male: Carapace, height 9.4, width 15.2, length 26.9 mm; areola, width 1.0, length 9.6 mm; rostrum, width 3.8, length 6.4 mm; abdomen, length 27.7 mm; right chela, length of inner margin of palm 7.5, width of palm 11.4, length of outer margin of hand 28.7, length of dactyl 19.3 mm. Allotypic female: Carapace, height 8.0, width 11.6, length 22.6 mm; areola, width 0.70, length 7.8 mm; rostrum, width 3.2, length 5.9 mm; abdomen, length approx. 24 mm; right chela, length of inner margin of palm 5.2, width of palm 7.3, length of outer margin of hand 17.2, length of dactyl 11.3 mm.

Type locality.—Mill Creek, tributary of Cumberland River, east of Oglesby near Antioch Pike, 10 miles south of Nashville, Davidson County, Tenn. Dr. Shoup has kindly furnished the following information: This creek is a hard-water stream flowing over sand and rubble and in its upper reaches over limestone ledges. The banks are silty and muddy, and shade is provided by reeds and trees along its banks. Much of its course is through pasture and cultivated lands. In riffle areas the water has a slightly greenish cast on cloudy days. (M. O. alkalinity—154.0 p.p.m. on January 24, 1947.)

Disposition of types.—The holotypic male, the allotypic female, and the morphotypic male, form II, are deposited in the United States National Museum (no. 84072), and in addition five second-form males and one female, collected by R. S. Fleming (U.S.N.M. no. 77908) are designated as paratypes. Of the remaining paratypes, one male, form I, and one female are deposited in the University of Michigan Museum of Zoology; one male, form I, and one female in the Museum of Comparative Zoology; and 11 males, form I, one male, form II, two females, five immature males, and one immature female are in my personal collection at the University of Virginia.

Specimens examined.—Tennessee, Davidson County: Seven Mile Creek, 5 miles southeast of Nashville, November 11, 1944, two males, form I, one male, form II, and two females—C. S. Shoup, collector; Mill Creek, 10 miles south of Nashville, November 11, 1944, eight males, form I, one male, form II, and three females—C. S. Shoup, collector; Mill Creek at junction with U. S. Highway 41, about 3 or 4 miles south of Nashville, October 11, 1939, two males, form I—W. K. Smith, collector; same locality, August 15, 1936, five males, form II, and one female—R. S. Fleming, collector; Mill Creek at Antioch Pike, July 19, 1945, two males, form I, one male, form II (shed test), and four immature males—Mike Wright, collector.

Fleming (1939, **14**: 319) states: "All of these species (including *C. propinquus sanborni* Faxon) were present throughout the region studied . . . "; however, he cites only one locality in which this species was taken. I strongly doubt that his statement is correct, for Drs. Shoup and Wright have collected in a large number of localities in the Nashville region and have taken *O. shoupi* (= Fleming's *C. propinquus sanborni* Faxon) from only the localities cited above.

Variation.—The rostrum may or may not bear a median carina. The bearded condition of the cheliped which is pointed out in the description of the morphotypic male, form II, is best developed in young specimens and may be reduced or obsolete in older ones. As in most species the spiniform condition is accentuated in the younger specimens, and in the older ones very much reduced; further, in some of the females mirrored images of the annulus ventralis as described for the allotype occur.

Relationships.—*Orconectes shoupi* is a member of the *Limosus* section; it possesses short gonopods, the tips of which are separated for only a short distance. Its closest affinities are with *O. sloani* (Bundy) (1876:24), *O. tricuspis* Rhoades (1944:117), and *O. rafinesquei* Rhoades (1944:116). *O. shoupi* may readily be

distinguished from any other species of the *Limosus* section by the rostrum with thickened ridges and the long-fingered chelae—both of which resemble those of *O. rusticus placidus.* (see further remarks below.)

LIMOSUS SECTION

Ortmann (1931:64) defined the section of *Orconectes limosus* as follows: "Gonopods of male, short, rather thick up to near the tips, reaching to the coxopodites of the third peraeopod. Tips separated for a short distance only, each tapering to a point. Males with hooks on third, or on third and fourth peraeopods." In this section he included *O. harrisoni*, *O. sloani*, *O. indianensis*, *O. limosus*, *O. pellucidus pellucidus pellucidus*, and *O. pellucidus testii*.

Since 1931 Rhoades has described several additional species and subspecies belonging to the *Limosus* section, and in his *Crayfishes of Kentucky* (1944:117) recognized two groups of the section, and listed under them the species indicated below:

Limosus group—"characterized by strongly diverging tips of the gonopods." Species: *O. limosus* (Rafinesque), *O. sloani* (Bundy), and *O. indianensis* (Hay).

Rafinesquei group—"the tips of the first pleopod are both recurved in the same direction." Species: *O. rafinesquei* Rhoades, *O. tricuspis* Rhoades, *O. pellucidus pellucidus* (Tellkampf), *O. pellucidus testii* (Hay), *O. pellucidus australis* (Rhoades), *O. pellucidus packardi* Rhoades, *O. kentuckiensis* Rhoades, and *O. harrisoni* (Faxon)

It is questionable that the above subdivision of the section into the *Limosus* and *Rafinesquei* groups is based on true affinities: e.g., if the pleopod of *O. kentuckiensis* is compared with that of *O. sloani* and *O. tricuspis*, certainly it is more like that of the former. This relationship is seen not only in the first pleopod but also in the annuli ventralis of the two. It also seems to me that *O. harrisoni* is more nearly related to *O. sloani* than it is to *O. tricuspis* or *O. rafinesquei*. Except for the fact that the terminal elements of the first pleopods of the several subspecies of *O. pellucidus* are "recurved in the same direction" (and I might indicate that among the specimens I have examined of *pellucidus pellucidus* the terminal elements are straight), I can see no indication of closer affinities of these forms with the members of the *Rafinesquei* group than with those of the *Limosus* group—in fact, if any division of the *Limosus* section is made then it would seem that *O. inermis* and the various subspecies of *O. pellucidus* would constitute a natural group that should receive a status equivalent to that of the other subdivisions.

The problem of the status of *O. inermis* remains unsolved. Though I have seen relatively few specimens of the several subspecies of *O. pellucidus* I have examined several belonging to all of them, and none are like *O. inermis*. Perhaps it will be shown to be a subspecies of *O. pellucidus*; however, until future work will indicate intergradation between the two, it seems advisable to retain its specific status.

As might be expected, with the discovery of additional species the *Limosus* section has become decidedly less clear cut, and certain species exhibit characters transitional between the more typical members of the *Limosus* section and members of other sections of the genus. Even in Ortmann's diagnosis of the *Limosus* section quoted above the best character is stated on a relative basis, and a worker not already familiar with an over-all picture of the genus would have difficulty in deciding whether a given specimen belonged to the *Limosus* or *Propinquus* sections (Ortmann, 1931: 64, 65). The difficulty at the time that Ortmann diagnosed the section was not so great as it has been since the somewhat "atypical" *O. tricuspis*, *O. rafinesquei*, and *O. shoupi* have been added to the list of described species belonging to the section. In these species the terminal elements of the first pleopod are almost as slender and long as are those of some of the members of the *Propinquus* section (see Figs. 21, 23, 25). These obvious resemblances as well as the similarities of the annuli ventralis and other anatomical features between *O. propinquus propinquus* (Girard, 1852: 88) and *O. tricuspis* make the distinction between the two sections seem somewhat unnatural—i.e., there seem to me to be about as many resemblances between *O. tricuspis* and the subspecies of *O. propinquus* as between *O. tricuspis* and *O. sloani*, *O. limosus*, and *O. indianensis*. Furthermore, considering the pleopods alone, *O. kentuckiensis* is transitional between *O. limosus* and *O. sloani* on one side and *O. difficilis* (Faxon, 1898: 656) on the other—the latter at present being relegated to the *Virilis* section (Ortmann, 1931: 90). Rhoades (1944: 123) states in reference to the

affinities of *O. kentuckiensis* that it "represents a more advanced stage in the series of the 'Group rafinesquei'. The tips are stouter and more differentiated and the annulus is more depressed as in *sloani* and other members of the 'Group limosus'. In this character it resembles closely *O. immunis immunis*. Furthermore, it is not difficult to see a possible affinity to the 'Section of *C. virilis*' [=*O. virilis*] even in the gonopods of the male."

Whether these similarities are results of convergence or whether they indicate actual close relationships can hardly be determined until a more exhaustive study of the group (which will necessarily mean extensive collecting) is made. On the basis of the evidence at hand I find it difficult to consider these resemblances arising independently in the three sections.

The taxonomists working with the crayfishes of the Cambarinae have for a long time found it convenient to recognize "sections," "groups," and "subgroups," and even though there are certain species that on the bases of the diagnostic characters appear to be intermediate between two sections or groups, at least a temporary retention of their usage seems desirable. Whereas the limits of variation in the three sections of the subgenus *Orconectes* are not decidedly marked, and almost impossible to define in words, recourse to determined specimens or figures should alleviate difficulty in determining to which section or group any specimen in question belongs. For this reason I am including a sketch of the pleopods of all the species and subspecies (except *O. pellucidus testii*, of which I do not have a first form male) belonging to the *Limosus* section, and in addition, for comparative purposes, the pleopods of *O. propinquus propinquus* and *O. difficilis*.

KEY TO THE SPECIES AND SUBSPECIES OF THE LIMOSUS SECTION OF ORCONECTES

(BASED ON THE FIRST-FORM MALE)

1. Body pigmented, eyes well developed......2
   Body not pigmented, eyes reduced.........9
2. Terminal elements of first pleopod subequal in length and distinctly divergent (central projection directed cephalodistad and mesial process caudodistad)...............3
   Terminal elements of first pleopod subequal or not subequal in length, but central projection never bent cephalodistad—either straight, directed caudad, or caudodistad..4
3. Lateral surface of carapace with only one spine..............*O. indianensis* (Hay)
   Lateral surface of carapace with more than one spine......*O. limosus* (Rafinesque)
4. Central projection bent caudad at an angle greater than 45°....*O. harrisoni* (Faxon)
   Central projection directed distad or bent caudad at an angle less than 45°..........5
5. Terminal elements of first pleopod subequal in length or mesial process slightly longer than central projection...................................*O. tricuspis* Rhoades
   Mesial process never extending quite so far distad as central projection.............6
6. Central projection recurved (caudodistad) throughout its length; no median carina on rostrum....*O. kentuckiensis* Rhoades
   Central projection not recurved caudodistad throughout its length; median carina on rostrum present or absent..............7
7. Margins of rostrum thickened and concave laterad..............*O. shoupi* Hobbs
   Margins of rostrum not thickened, and subparallel or convergent up to base of lateral spines..............................8
8. Terminal elements of first pleopod widely separated and thick (heavy); tip of mesial process caudomesiad of central projection ....*O. sloani* (Bundy)
   Terminal elements of first pleopod not widely separated, and slender and tapering; tip of mesial process caudolaterad of central projection......*O. rafinesquei* Rhoades
9. Margins of rostrum uninterrupted; acumen not distinctly set off from rest of rostrum ....*O. pellucidus testii* (Hay)
   Margins of rostrum interrupted; acumen distinctly set off from rest of rostrum......10
10. Cephalic margin of pleopod without a shoulder at base of central projection; however, either straight or curved..............11
    Cephalic margin of pleopod with an angular or rounded shoulder..................12
11. Cephalic surface of first pleopod in region of central projection straight; mesial process directed distad and extending distad beyond central projection....................*O. pellucidus pellucidus* (Tellkampf)
    Cephalic surface of first pleopod in region of central projection curved; mesial process directed caudodistad and somewhat laterad, and not extending distad beyond central projection.....*O. inermis* Cope
12. Shoulder on cephalic margin at base of central projection rounded; hooks present only on ischiopodites of third pereiopods..............*O. pellucidus australis* (Rhoades)[5]

[5] The holotype of *O. pellucidus australis* has a small short acute spine (probably corresponding to the caudal process seen in many members of the genus *Procambarus*), which in lateral aspect lies between the central projection and the mesial process.

Shoulder on cephalic margin at base of central projection distinctly angular; hooks present on ischiopodites of third and fourth pereiopods. *O. pellucidus packardi* Rhoades.

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ORNITHOLOGY—*The races of the black-throated sunbird,* Aethopyga saturata *(Hodgson)*.[1] H. G. DEIGNAN, U. S. National Museum.

For more than 30 years the race of *Aethopyga saturata* common on the mountains of northwestern Siam has, without any direct comparison of specimens, been recorded as *sanguinipectus* (a name originally applied to the form of the Karen Hills). Topotypes of *sanguinipectus* and of its presumed synonym *waldeni* (described from Mount Muleyit in Tenasserim) are nowhere available in America, but reference to the first descriptions and especially to Shelley's *Monograph of the Nectariniidae*, pt. 6, 1878, pp. 37–38 and colored plate (where the description is taken from the types of *sanguinipectus* and the illustration from the types of *waldeni*), has shown that *sanguinipectus* has the entire throat (except only the center of the chin) metallic blue or violet and is thus quite different from the Siamese bird, as well as from the several populations of Indochine that have been masquerading under its name. This discovery has made necessary a revision of the species, with the result that the number of races has been increased from the five accepted by Delacour (Zoologica **29**: 34. 1944) to nine, of which three are here described for the first time.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received June 10, 1947.

Material essential to the prosecution of this study has been courteously sent me by the Museum of Comparative Zoology (M.C.Z.), the American Museum of Natural History (A.M.N.H.), the Princeton Museum of Zoology (P.M.Z.), the Academy of Natural Sciences of Philadelphia (A.N.S.P.), and the Chicago Natural History Museum (C.N.H.M.).

1. **Aethopyga saturata saturata** (Hodgson)

[*Cinnyris*] *Saturata* Hodgson, India Rev. and Journ. Foreign Sci. and Arts **1** (7): 273. Oct. 1836 (Nepal).

Nectarinia hodgsonis [*sic*] Jardine, Naturalist's Library **36** [Nectariniidae]: 240, 269 [where spelled *hodgsoni*], pl. 28, 1843 (Nepal).

Range. Himalayas, from Garhwal to Bhutan.

Remarks. The reference to Hodgson's name is incorrectly cited by Stuart Baker (Fauna of British India, birds, ed. 2, **7**: 285. 1930) as "Ind. Review, vol. ii, p. 273, 1837." Sherborn (Index Animalium, p. 5753) gives "India Rev. I. 1837, 273." According to the researches of the late C. W. Richmond, the first volume of the India Review appeared in 12 monthly installments from April 1836 to March 1837, and the proper citation is that given above.

2. **Aethopyga saturata assamensis** (McClelland)

Cinnyris assamensis McClelland, Quart. Journ.

Calcutta Med. and Phys. Soc. **1** (3): 322. July 1837 (Assam). *Nomen nudum!*

Cinnyris Assamensis McClelland, Proc. Zool. Soc. London **7**: 167. Mar. 1840 (Assam; type locality here restricted to the neighborhood of Sadiya, Sadiya Frontier Tract, Assam Province, India).

Range.—Assam; Burma (north); Yunnan (west).

Remarks.—Mayr (Ibis 1938: 302) has shown that the bird of northern Burma, while most like *saturata*; differs from it by a broadening of the yellow band across the lower back and by a slightly shorter wing and a much shorter tail. For this population the old name *assamensis* may be revived.

3. Aethopyga saturata sanguinipectus Walden

Æthopyga sanguinipectus Walden, Ann. Mag. Nat. Hist. (4) **15**: 400. June 1875 ("Tonghoo hills [Karen-hee]," error; type locality corrected to "the Tonghoo and Karen-nee hills" by Wardlaw Ramsay, *in* The ornithological works of Arthur, Ninth Marquis of Tweeddale, p. 414, 1881).

Æthopyga Waldeni Hume, Stray Feathers **5** (1): 51. Apr. 1877 (Mount Muleyit, Amherst District, Tenasserim Division, Burma).

Range.—Southeastern Burma, from lat. 19° N. south to lat. 14° N. (but see Remarks).

Remarks.—Shelley (*loc. cit.* in introductory paragraph above) has observed that "the illustrations of both sexes are taken from the specimens collected by Mr. Davison, and described as *Æ. waldeni* by Mr. Hume, who has kindly forwarded them to me from India to compare with the types of *Æ. sanguinipectus*, to which species they evidently belong." It may be hoped that some latter-day students in London will compare the two again to learn whether they belong to the same *subspecies!*

The one bird of *sanguinipectus*-type available to me is a male from Mount Nwalabo (lat. 14° N.), which may or may not be properly placed under this name. The synonymy and range given above for *sanguinipectus* must therefore be considered only tentative.

4. Aethopyga saturata anomala Richmond

Æthopyga anomala Richmond, Proc. U. S. Nat. Mus. **22**: 319. May 12, 1900 (Khao Sung, peninsular Siam at lat. 7°32′ N., long. 99°50′ E.).

Range.—Specimens are known from Khao Soi Dao (lat. 7°20′ N., long. 99°50′ E.), Khao Nok Ra (lat. 7°25′ N., long. 99°55′ E.), Khao Nam Pliu (lat. 7°35′ N., long. 99°50′ E.), and the type locality, all hills in the range dividing the Siamese provinces of Phatthalung and Trang.

5. Aethopyga saturata wrayi Bowdler Sharpe

Æthopyga wrayi Bowdler Sharpe, Proc. Zool. Soc. London 1887, pt. 3: 440, pl. 38, fig. 2. Oct. 1 (Larut Range, at elev. 4,400 ft., Perak State, Malaya).

Range.—Mountains of Malaya from northern Perak to southern Selangor and in Pahang.

6. Aethopyga saturata petersi, n. subsp.

Type.—C.N.H.M. no. 76209, adult male, collected at Pa Kha (lat. 22°32′ N., long. 104°18′ E.), Laokay Province, Tongking, on December 28, 1929, by J. Delacour and P. Jabouille (original number 3312).

Diagnosis.—The adult male of the new form is immediately distinguishable from those of *A. s. saturata* (Nepal), *A. s. assamensis* (Assam), and *A. s. anomala* (peninsular Siam) by having the lower breast sulphur yellow, conspicuously streaked with blood red.

From those of *A. s. sanguinipectus* (Karen Hills) and *A. s. johnsi* (southern Annam) it is separable by having the entire area between the metallic-blue mustachial streaks, from chin to breast, unglossed black (*not* metallic blue).

It is, in fact, nearest the geographically remote *A. s. wrayi* (Malaya), from which it may be known by its having the sulphur-yellow breast patch more clearly defined and posteriorly more extensive, the red streaks on the breast patch more numerous, and the remaining under parts a slightly paler, more yellowish, less grayish, olive green.

Range.—Yunnan (southeast); Tongking; Annam (north); Haut-Laos; Southern Shan States (Kengtung State); northern Siam (Chiang Rai and Nan Provinces).

Specimens examined.—34 males, 3 females.

Remarks.—This race is named in honor of James Lee Peters, of the Museum of Comparative Zoology.

7. Aethopyga saturata galenae, n. subsp.

Type.—U.S.N.M. no. 331074, adult male, collected on Doi Langka (Khao Pha Cho), northern Siam at lat. 19°00′ N., long. 99°25′ E.,

on November 10, 1930, by Hugh M. Smith (original number 4307).

Diagnosis.—The adult male is nearest that of *A. s. petersi* (Tongking) but differs by having the sulphur-yellow breast patch posteriorly more extensive and less clearly defined from the remaining underparts, which are olivaceous-yellow (*not* grayish olive-green).

The adult female is separable from that of *A. s. petersi* by having the underparts suffused posteriorly with yellow, rather than a uniform grayish olive-green.

Range.—Siam (northwest).

Specimens examined.—18 males, 3 females.

Remarks.—Of four males from Doi Ang Ka (lat. 18°35′ N., long. 98°30′ E.), three are inseparable from topotypical *A. s. galenae;* the exceptional specimen has the majority of the feathers of the upper half of the throat wholly or partly metallic blue and thus shows approach to *A. s. sanguinipectus-waldeni* of Mount Muleyit. It is highly probable that birds of the unexplored hills lying between Ang Ka and Muleyit will prove to be true *sanguinipectus-waldeni.*

This race is named in honor of my mother.

8. **Aethopyga saturata ochra,** n. subsp.

Type.—C.N.H.M. no. 91613, adult male, collected at Thateng (lat. 15°31′ N., long. 106°22′ E.), Saravane Province, Bas-Laos, on November 26, 1931, by J. Delacour (original number 312).

Diagnosis.—The adult male is nearest that of *A. s. galenae* (northwestern Siam), from which it differs (and so much the more from that of *A. s. petersi*) by having the sulphur-yellow breast patch posteriorly still more extensive and scarcely defined at all from the remaining underparts, which are more strongly suffused with yellow then in any other race.

The adult female seems to be identical with that of *A. s. galenae.*

Range.—Bas-Laos (Boloven Plateau).

Specimens examined.—7 males, 2 females.

9. **Aethopyga saturata johnsi** Robinson and Boden Kloss

Æthopyga sanguinipectus johnsi Robinson and Boden Kloss, Ibis (11) 1 (4): 621. Oct. 23, 1919 (Dran, Haut-Donai Province, southern Annam).

Range.—Southern Annam (Langbian Plateau).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

413TH MEETING OF BOARD OF MANAGERS

The 413th meeting of the Board of Managers, held in the Cosmos Club, December 15, 1947, was called to order at 8:10 P.M. by the President, Dr. WALDO L. SCHMITT. Others present were: H. S. RAPPLEYE, H. A. REHDER, H. B. COLLINS, Jr., F. G. BRICKWEDDE, F. L. MOHLER, J. S. WADE, W. W. RUBEY, L. E. YOCUM, W. A. DAYTON, M. A. MASON, C. L. GARNER, and C. L. GAZIN.

Eighteen persons were elected to membership. Dr. PERCY W. BRIDGMAN, a member of the Academy and a Nobel Prize winner, who has spoken before the Academy, was proposed for Honorary Membership. The Board voted unanimously that he be awarded this distinction. Ten nominations for resident membership were presented.

The Secretary, Dr. C. L. GAZIN, reported the death of Dr. DWIGHT F. WINDENBURG on November 14, 1947, formerly with the David Taylor Model Basin. He also reported the resignations of Drs. ALBERT E. LONGLEY and JOHN B. MERTIE, Jr. The Board accepted these resignations, with regret, effective December 31, 1947. The request of Dr. H. C. OBERHOLSER, who has paid dues from 1906 through 1947 and who has retired from the gainful practice of his profession, that he be placed on the retired list of Academy members was approved by the Board.

The Secretary announced that he received, on November 28, 1947, the nomination of Dr. GILBERT GROSVENOR for President of the Academy in 1948. [This candidate subsequently withdrew.—Ed.]

The Treasurer, H. S. RAPPLEYE, requested that he be authorized to transfer the present two investment certificates, amounting to $5,000 in total, in the First Federal Savings &

Loan Association, to a single account-book form as proposed by the Association. This request was granted.

The meeting was adjourned at 9:42 P.M.

C. L. GAZIN, *Secretary.*

NEW MEMBERS OF THE ACADEMY

There follows a list of persons elected to membership in the Academy, by vote of its Board of Managers, since December 16, 1946, who have since qualified as members in accordance with the bylaws. (See also previous list in May 15, 1947, issue of the Journal.) The bases for election are stated with the names of the new members.

RESIDENT

Elected December 16, 1946

WALTER A. MCCUBBIN, botanist, Bureau of Entomology and Plant Quarantine, in recognition of his contributions to the scientific basis of plant quarantines and the means of distribution of parasitic fungi.

DEAN B. COWIE, physicist, Department of Terrestrial Magnetism, Carnegie Institution of Washington, in recognition of his work in the construction of the cyclotron at the Department, for many cooperative researches in which cyclotron products made by him were used, and especially his work on the distribution of antimony in Filaria infections.

Elected January 13, 1947

MARK W. WOODS, botanist, National Cancer Institute, in recognition of his studies on the cytology of plant virus diseases and the origin and nature of viruses.

JOHN W. ALDRICH, biologist, U. S. Fish and Wildlife Service, in recognition of his contributions to knowledge of the taxonomy and distribution of North American birds.

Elected April 14, 1947

PHILIP DRUCKER, anthropologist, Bureau of American Ethnology, Smithsonian Institution, in recognition of his contribution to the ethnology of the Northwest coast and to the archaeology of these regions and of Veracruz, Mexico.

HARRIET L. FRUSH, chemist, National Bureau of Standards, in recognition of her contribution to organic chemistry, more especially the development of the first satisfactory mechanism for the production of orthoesters from transacetohalogen compounds and the development of methods for the separation of manuric and galacturonic acids.

CAMILLE L. LEFEBVRE, botanist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of his researches in plant pathology, especially fungous diseases of forage crops.

CURTIS W. SABROSKY, entomologist, Bureau of Entomology and Plant Quarantine, in recognition of his contributions to the classification of the Diptera and in particular his work on the taxonomy of the family Chloropidae.

WALTER B. LANG, geologist, U. S. Geological Survey, in recognition of the pioneer study of the stratigraphy and sedimentation of the Permian of the Southwestern United States and its application to the discovery of potash and the development of a self-sufficient potash industry.

LOUISE M. RUSSELL, entomologist, Bureau of Entomology and Plant Quarantine, in recognition of her contributions to the taxonomy of the sternorhynchous Homoptera, in particular her studies on the classification of the coccid genus *Asterolecanium*, on various groups of the whitefly family Aleyrodidae, and on various species of the Psyllidae.

GEORGE M. FOSTER, Jr., anthropologist, Institute of Social Anthropology, Smithsonian Institution, in recognition of his contributions to the development of the science of ethnology in Mexico.

FENNER A. CHACE, Jr., biologist, U. S. National Museum, in recognition of his contributions in zoology, especially in the field of Crustacea.

RUTH E. GORDON, bacteriologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of her contributions to bacteriology, especially her researches on the acid-fast and on the spore-forming bacteria.

Elected October 6, 1947

HUBERT R. SNOKE, engineer, National Bureau of Standards, in recognition of his important work on roofing and building materials.

ELLIOTT B. ROBERTS, engineer, U. S. Coast and Geodetic Survey, in recognition of his contributions in the development of oceanographic instruments and techniques, and in exploration

and geodetic surveying in the Philippine Islands, the Aleutian Islands, and other areas.

CURTIS J. HUMPHREYS, physicist, National Bureau of Standards, in recognition of his work on spectroscopy, including Zeeman effect and intensity measurements in the spectrum of the solar chromosphere.

RICHARD K. COOK, physicist, National Bureau of Standards, in recognition of his contributions to acoustics and in particular to the absolute measurement of sound intensity.

NONRESIDENT

Elected October 6, 1947

THEODORE E. WHITE, paleontologist, Museum of Comparative Zoology, Cambridge, Mass., in recognition of his contributions to vertebrate paleontology, in particular to the morphology of primitive tetrapods.

PHILOSOPHICAL SOCIETY

1268th Meeting

The 1268th meeting, the occasion of the Fifteenth Joseph Henry Lecture, was held in the Auditorium of the U. S. National Museum, May 25, 1946, President DEFANDORF presiding.

Program: HARVEY FLETCHER, Bell Telephone Laboratories: *The pitch, loudness and quality of musical tones.* This paper has been published in full in the American Journal of Physics **14**: 215–225. 1946.

1269th Meeting

The 1269th meeting was held in the Cosmos Club Auditorium, October 12, 1946, President DEFANDORF presiding.

Program: H. W. WELLS, Department of Terrestrial Magnetism: *Panoramic ionospheric recorder.*—The application of a new technique for ionospheric research, developed at the Department of Terrestrial Magnetism, Carnegie Institution of Washington, under sponsorship of the United States Army Signal Corps, has led to the discovery of hitherto unsuspected rapid motions and fluctuations. The panoramic ionospheric recorder in development, operating over a range 1.0 to 20.0 megacycles per sec and registering the ionospheric echoes on a single frame of 16-mm motion-picture film, was described briefly. This apparatus makes two records each minute in normal operation. Projection of the series of 16-mm records thus obtained as a motion picture gives a condensation of time scale and a continuity of events which reveal ionospheric fluctuations of a surprising nature.

During periods of ionospheric and magnetic storms, rapidly moving clouds are "tracked" into the F2 (outer) layer. Upon merging of the clouds with the F2 layer the ionization is seen to increase, and downward rippling motions suggest an extension of the effect into lower regions of the ionosphere.

The technique of recording offers considerable promise both as a research tool leading to a better understanding of atmospheric physics and as an educational aid in training of personnel for ionospheric investigations. (*Author's abstract.*)

NEWBORN SMITH, National Bureau of Standards (paper read by Mr. SILBERSTEIN): *Longitude effect in F2-layer characteristics.*—Before adequate world-wide ionospheric observations had been made, it was assumed that the monthly average F2-layer critical frequencies and virtual heights were the same, at the same local time, for stations at the same geographic latitude but different longitudes. Radio operating data indicated, however, that this assumption was questionable, and ionospheric observations from the world-wide network of stations established during the war showed a pronounced longitudinal variation, apparently associated with differences in geomagnetic latitude. This paper presented the evidence for the longitude effect, indicating how it led to the operational use of separate ionospheric prediction charts for the different world zones. (*Author's abstract.*)

1270th Meeting

The 1270th meeting was held in the auditorium of the Cosmos Club, October 26, 1946, President DEFANDORF presiding.

Program: N. P. HAYS, Wright Field: *Polar navigation.*—Major Hays discussed his part as navigator in the preparations and flight of the Pacusan Dreamboat from Oahu to Cairo by way of the geomagnetic pole. (*Secretary's abstract.*)

SIR ROBERT WATSON-WATT, Radio Board of Great Britain: *Air navigation by radio methods.*—The early history, development, and use of radio were discussed. The use of radio reflections from the ionosphere and other small

reflections was also emphasized. (*Secretary's abstract.*)

1271st Meeting

The 1721st meeting was held in the auditorium of the Cosmos Club, November 9, 1946, President DEFANDORF presiding.

Program: J. H. CURTISS, National Bureau of Standards: *High-speed digital computing machines, Pt. 1.*—The chief purpose of this paper was to list and describe the various current Federally financed projects in the field of automatic digital computing machines. Those already in existence, listed in the approximate order of completion, are: the "IBM Automatic Sequence Controlled Calculator" at Harvard University; two small Bell Telephone Laboratories relay computers, of which one is at the Naval Research Laboratory and the other is at Fort Bliss, Tex.; five small relay calculators developed by the International Business Machines Corporation, of which one is at the Naval Proving grounds at Dahlgren, two are at the Ballistics Research Laboratory of the Aberdeen Proving Grounds, and two are at Watson Laboratories in New York City; and finally, the electronic "ENIAC," built at the University of Pennsylvania for Aberdeen. Two large Bell Telephone relay computers are almost finished; one is for Aberdeen and the other for the Langley Memorial Laboratory of N.A.C.A. Harvard University is constructing a large relay machine for the Naval Proving Grounds.

Important development projects are: (1) At the National Bureau of Standards, construction of large-capacity digital computers for the U. S. Navy and the Bureau of the Census, and a component development project for the Ordnance Department of the Army; (2) at the University of Pennsylvania, construction of another electronic digital computer for Aberdeen; (3) at the Institute for Advanced Study and RCA Laboratories at Princeton, N. J., construction of an electronic digital computer; (4) at the Massachusetts Institute of Technology, construction of a large electronic digital simulator for the Navy and also a component research project financed by the Rockefeller Foundation. (*Author's abstract.*)

S. N. ALEXANDER, National Bureau of Standards: *High-speed digital computing machines, Pt. 2.*—There are two basic approaches by which scientific computations can be reduced to an automatic operation. These are the analogue and the digital procedures. The analogue procedure had been exploited to the greater extent prior to the war. During the war the need for greater accuracy and flexibility led to intensive development of the digital procedure. The first of these machines, using electromechanical devices, was developed jointly by Harvard University and the International Business Machines Corporation. Next, the Bell Telephone Laboratories developed a computing machine using electrical relays. Finally, an essentially electronic machine of greatly increased operating speed was constructed at the University of Pennsylvania for the Army Ordnance. These applications of electromechanical and electronic techniques pointed the way toward making available the flexibility that is inherent in the digital procedure. An immediate goal is to apply this flexibility to the solution of partial differential equations. To accomplish this will require the development of still faster electronic machines of much greater capacity. Consequently, the present program for the development of large-scale, high-speed digital computing machines is being pursued with even more vigor than during the war. (*Author's abstract.*)

1272d Meeting

The 1272d meeting was held in the auditorium of the Cosmos Club, November 23, 1946, President DEFANDORF presiding.

Program: R. J. SEEGER, Naval Ordnance Laboratory: *Shock-wave phenomena.*—A significant property of linear differential equations is the principle of superposition of solutions, e.g., Huygens's principle in physics. Is there a corresponding principle in the case of nonlinear differential equations? Shock-wave phenomena presents a means of studying this question from the viewpoint of Nature's own integrations. This paper formed essentially a report of the research along this line initiated at the Bureau of Ordnance (Navy Department) by J. VON NEUMAN. It started with optical illustrations of shock waves occurring in ballistics, air jets, wind tunnels, and explosions. The mathematical concept of a shock wave was presented, leading to the simple step-shock model described by the Rankine-Hugoniot equations. This model has been used in the investigation

of the interaction of shock waves. The theoretical predictions for reflection from a rigid wall were compared with the experimental observations. For so-called regular reflection the simple model is adequate. In the case of Mach reflection, which involves an intersection of three shock waves (and a temperature discontinuity) moving away from the wall, there is an enigma that can not be solved by any simple physical picture such as uniform pressure between the shocks or even by Prandtl-Meyer modification of this uniformity. (*Author's abstract.*)

F. J. WEYL, Naval Ordnance Laboratory: *Optical analysis of supersonic flow.*—The variations in density, which will be found whenever a compressible fluid is engaged in nonuniform motion, imply accompanying variations in the local index of refraction. Consequently a beam of transluminating light will be disturbed by the presence of flow without, in its turn, disturbing the flow. This fact is used in three basically different fashions, depending on the optical apparatus inserted into the light path, to obtain records of the density variations in the compressible flows. Referred to as the shadowgraph, the schlieren, and the interferometric methods, they render visible respectively the total distortion, the change in direction, and the change in the time of transit experienced by the transluminating light beam on account of the presence of the flow. These three methods were first discussed from a quantitative analytic viewpoint and were then illustrated individually by typical records allowing a direct comparison of their respective strengths and weaknesses. (*Author's abstract.*)

1273d Meeting

The 1273d meeting, the 76th annual meeting, was held in the auditorium of the Cosmos Club, December 7, 1946, President DEFANDORF presiding.

The report of the treasurer, confirmed by the report of the auditing committee, showed an income from dues and interest on investments of $1357.54 and expenditures of $1137.20, leaving a net gain of $220.34 on ordinary expenses. The ordinary expenses were at the rate of $3.27 per member. The total estimated assets of the Society showed a decrease of $271.76 from $16,694.19 as of December 1, 1945, to $16,377.43 as of December 1, 1946.

The joint report of the Secretaries showed an active membership of 359 as of December 1, 1946—a net increase of 12 members during the year. The following persons were elected during the year: W. D. APPEL, C. E. BARTHELL, R. D. BENNETT, T. J. CARROLL, G. E. DAVIS, R. F. GELLER, P. H. GIROUARD, D. HARKIN, W. N. HARRISON, MARY W. HODGE, H. J. HOGE, R. L. MCKINNEY, D. E. PARSONS, G. W. PETERSON, E. K. PLYLER, B. P. RAMSAY, E. B. ROBERTS, L. H. RUMBAUGH, G. B. SABINE, G. H. SHORTLY, H. S. STEWART, R. D. STIEHLER, E. J. STOVALL, JR., R. WELLER, F. J. WEYL, W. J. WYATT.

The Secretaries reported the deaths of PAUL BROCKETT, W. N. HAMILTON, and W. P. WHITE.

Following the report of the Committee on Elections, these officers were declared elected for the year 1947: *President*, FRED L. MOHLER; *Vice-Presidents*, WALTER RAMBERG and KENNETH L. SHERMAN; *Recording Secretary*, WALTER L. CHENEY; *Treasurer*, FRANK C. KRACEK; *Members-at-Large of General Committee*, KARL F. HERZFELD, and LAWRENCE A. WOOD.

Program: R. P. PETERSON, Johns Hopkins Applied Physics Laboratory: *Exploration of the upper atmosphere by rockets, Pt. 1.*—A review of the advancements in cosmic rays shows that measurement vs altitude has been important in illuminating the subject. The measurement of residual ionization vs altitude by Hess and by Koehorster in 1912 gave the first positive evidence of the extraterrestrial nature of the cosmic radiation. Later, the measurements of Bowen, Millikan, and Neher of ionization vs altitude at various latitudes indicated the charged-particlelike character of the primaries and gave an energy spectrum for the primary radiation. At present there remain important unsolved problems; the mesatron component increases to the highest altitudes to which measurements have been made, yet its radioactive character insists that it is a secondary and therefore that it must eventually decrease; there is reported an overabundance of soft component at higher altitude; primary particles and their basic interactions (at energies 10,000 times the highest now sought for in man-made machines), which produce the soft and mesatronic secondaries appear to be largely observable only above the highest balloon flights.

This paper described the G. M. telescope of the type that Schein has used. This telescope measures total ionizing flux and compares the penetrating ionizing flux with the penetrating nonionizing flux, which converts in 2 cm of lead. The paper also described the arrangement used in the V-2 and presented a short discussion of the results obtained. There was indicated a need for additional verification, because of a rather large and unexpected presence of a nonionizing component of the primaries, or energy greater than 10^9 *EV* and capable of converting in 2 cm of lead.

Finally, there was presented a general description of data recovery from such rocket flights including results of aerodynamic spoiling to obtain lower landing speeds for the recovery of mechanical recorders, air sample bottles, cameras, spectrographs, etc. (*Author's abstract.*)

H. E. Newell, Naval Research Laboratory: *Exploration of the upper atmosphere by rockets, Pt. 2.*—The principal features of the V-2 rocket and its usefulness as a vehicle for upper-atmosphere experimentation were discussed. Following a review of the general aspects of upper atmosphere research including a discussion of the recovery problems, there was a discussion of the Naval Research Laboratory's work on solar spectroscopy, cosmic rays, pressure measurements, and ion-density measurements in the ionosphere. The paper was illustrated by means of slides pertaining to the October 10 V-2 flight at White Sands, N. Mex. (*Author's abstract.*)

1274th Meeting

The 1274th meeting was held in the auditorium of the Cosmos Club, January 4, 1947, President Mohler presiding.

The retiring president, Francis M. Defandorf, National Bureau of Standards, delivered his presidential address on the subject *The measurement of high voltage.* This address will be published in full in the Journal.

1275th Meeting

The 1275th meeting was held in the auditorium of the Cosmos Club, January 18, 1947, President Mohler presiding.

Program: R. S. Burington, Bureau of Ordnance: *The concept (and misconcept) of equivalence.*—This paper in expanded form is published in this number of the Journal (**38:** 1–11. 1948).

1276th Meeting

The 1276th meeting was held in the auditorium of the Cosmos Club, February 1, 1947, President Mohler presiding.

Program: James M. Klaasse, Naval Ordnance Laboratory: *Airborne magnetometer in geophysical exploration, Pt. 1.*—The magnetic airborne detector AN/ASQ-3A was developed by the Naval Ordnance Laboratory and the Bell Telephone Laboratories and was produced by the Western Electric Co. for use in the U. S. Navy's Bureau of Aeronautics for locating submarines from aircraft. Modified systems of this type have been used extensively by the Naval Ordnance Laboratory and the U. S. Geological Survey in airborne geophysical surveys throughout the United States and in Alaska.

In the magnetometer described, detection of a magnetic field employs an inductor with nearly ideal magnetization and saturation characteristics and negligible hysteresis. When the inductor winding is driven well beyond saturation field for the core material by a sine-wave current, the resulting distortion of flux wave-form produces harmonics of the driving frequency. The even-harmonic content is proportional to the magnetic field applied along the inductor axis. The second harmonic is selected by suitable filtering. Three such inductors are arranged mutually perpendicular. Two of these are used in a servo system to maintain automatically the axis of the third along the direction of the total field, and also to compensate for flight errors in the orientation system. A controlled variable direct current is supplied to the third inductor winding to suppress the total field to a small fraction of the earth's field. The low-frequency response of the system permits continuous recording of the earth's magnetic field intensity and anomalies as small as 10^{-5} gauss (1 gamma) while airborne. (*Author's abstract.*)

F. Keller, U. S. Geological Survey: *Airborne magnetometer in geophysical explorations, Pt. 2.*—The adaptation by the Geological Survey in cooperation with the Naval Ordnance Laboratory of the AN/ASQ-3A Magnetic Airborne Detector to problems of exploration in geophysics has made it possible to produce

maps of large areas showing total intensity variations of the earth's magnetic field with greater accuracy and speed and with less expense than by ground measurements.

The U. S. Geological Survey obtains the data by towing the magnetic detector element behind a twin-engined airplane in a streamlined housing called a "bird." Variations in magnetic intensity are recorded on a tape in the plane. The location of the plane is determined at all times by a gyroscopically stabilized Sonne continuous strip camera. A system of electrically operated counters and edge markers make it possible to correlate recognizable ground check points with the strip film and magnetometer record.

Magnetic surveys of over 120,000 square miles in areas which covered extreme contrasts of geological and magnetic environments have proved the value of the airborne magnetometer as a reconnaissance tool in exploration for mineral resources. (*Author's abstract.*)

1277th Meeting

The 1277th meeting was the occasion of the Sixteenth Joseph Henry Lecture and was held in the auditorium of the U. S. National Museum, February 15, 1947, President MOHLER presiding.

Program: JESSE W. BEAMS, Professor of Physics in the University of Virginia: *High centrifugal fields.* This address has been published in full in the JOURNAL **37**: 221–241. July 1947.

1278th Meeting

The 1278th meeting was held in the auditorium of the Cosmos Club, March 1, 1947, President MOHLER presiding.

Program: U. FANO, National Bureau of Standards: *Contributions of physics to biology, Pt. 1.*—The borderland between physics and biology is today the subject of widespread interest, especially from the side of young physicists, who think of making it their main line of work. It seems timely, therefore, to examine critically which specific, actual or potential, lines of endeavor should go under the name of biophysics. A few lines are well defined, such as: (*a*) the design, production, and employment of physical tools which help in solving biological problems; this is primarily a branch of applied physics; (*b*) the investigation of biological problems which involve physical measurements and tools; this requires knowledge of physical apparatus and techniques belonging primarily to biology as far as its motivation and methodology are concerned; (*c*) the participation of workers with training and experience in physics in the investigation of biological problems; this has often proved extremely effective.

It should be stressed that the field of endeavor is a biological one and physics plays no further part than lending ways of thought and methods of approach to problems. (*Author's abstract.*)

G. GAMOW, The George Washintgon University: *Contributions of physics to biology, Pt. 2.*—Until comparatively recent time the phenomena of life were so widely separated from familiar physical and chemical phenomena in inorganic matter that it seemed that the gap between the two could never be covered. This led to various "vitalistic" theories which insisted that the phenomenon of life is *principally* different from the ordinary physical phenomena and requires for their explanation some peculiar force known as "vis vitalis."

The recent progress of biology seems to cover the existing gap. In fact, the things like *viruses* and *genes* seem to represent the "missing links" between organic and inorganic matter. Although there is little doubt that *viruses* and *genes* represent the ordinary (although very complex) chemical molecules obeying the ordinary laws of quantum chemistry, they are also attributed to all basic properties of living organisms.

It is time now to attack the problem of these elementary living organisms from the purely physical point of view, and, while the biologists dig deeper and deeper into the properties of these entities from the complex and of biological forms, the physicist may be expected to approach the problem from the other end and "build up" the theory of gene and virus molecules on the basis of our present vast knowledge concerning the properties of atoms and atomic combinations. Just as the hydrogen atom represents the simplest model of atomic structure, and the deuteron the simplest nucleus, virus-particles are most probably the simplest biological models which can be treated theoretically.

Although there are still tremendous difficul-

ties ahead, we may not be so far from the possibility of constructing the model of the simplest living unit on the basis of purely atomic considerations. (*Author's abstract.*)

1279th Meeting

The 1279th meeting was held in the auditorium of the Cosmos Club, March 15, 1947, President Mohler presiding.

Program: S. E. Forbush, Department of Terrestrial Magnetism: *Cosmic rays from the sun?*—During the past 10 years three unusual and sudden increases in cosmic-ray intensity, lasting several hours, have been observed simultaneously in different parts of the world except at the Equator where no increase was observed. All three increases began nearly simultaneously with unusually long and intense radio-fadeouts and solar-flares. The cosmic-ray increases were similar and simultaneous on the day and night side of the earth. Magnetograms from several magnetic observatories indicate that the increase in cosmic-ray intensity can not be ascribed to changes in the earth's magnetic field. While the increases in cosmic-ray intensity might be ascribed to changes in the sun's general magnetic field which would permit more cosmic rays from outer space to reach the earth, such mechanism should be equally effective whether the solar-flare occurred in the front or back side of the sun. This with other arguments indicates that changing magnetic fields associated with a sunspot or flare may act as a magnetic accelerator for charged particles. Similar processes on stars might account for all cosmic rays. (*Author's abstract.*)

P. H. Abelson, Department of Terrestrial Magnetism: *The transuranic elements.*—The paper reviewed the facts leading to the discovery of neptunium. The nuclear and chemical properties of the transuranic elements were discussed. Possible methods of producing elements of higher atomic number than 96 were described. These included the bombardment of uranium or plutonium with high speed carbon, oxygen, or other nuclei. (*Author's abstract.*)

1280th Meeting

The 1280th meeting was held in the auditorium of the Cosmos Club, March 29, 1947, President Mohler presiding.

Program: Hugh L. Dryden, National Bureau of Standards: *Exploring the fundamentals of aerodynamics.*—This paper has been published in full in the Journal **37:** 145–156. May 1947.

1281st Meeting

The 1281st meeting was held in the auditorium of the Cosmos Club, April 12, 1947, President Mohler presiding.

Program: A. H. Bennett, American Optical Co.: *The phase contrast microscope.*—The older microscopic methods are particularly useful for certain types of specimens, but for materials whose details have little absorption differences but differences in optical path, the phase method has advantages. In phase microscopy such microscopic details are imaged as brightness differences to which the eye or photographic plate are sensitive. Work leading to phase microscopy was done by Abbé (prior to 1892), Bratuschek (1892), Rheinberg (1904), and Conrady (1905). Zernicke (1935) described the application of the phase contrast method to microscopy. Burch and Stock (1942) described their results using simplified equipment. Study of the theory, application, and apparatus for the method was begun by Richards, Osterberg, Jupnik, and the writer in 1941. In phase microscopy an annular ring placed near the lower focal plane of the substage condenser acts as a secondary light source. This ring is imaged by the condenser and the objective onto a diffraction plate which by means of evaporated metal and dielectric films, alters the amplitude and phase relationships between the light undeviated by the specimen and the diffracted light. The light distribution in the image formed under the above conditions is determined by means of diffraction theory. (*Author's abstract.*)

O. W. Richards, American Optical Co.: *Applications of the phase contrast microscope.*—While theoretical considerations indicate the possibility of a large number of diffraction plates, a relatively small number serve the needs of practical microscopy. Bright contrast is useful in counting and for finer details. Dark contrast is useful and sometimes is preferred as the image resembles that from stained preparations. Detail is brought out in living cells, emulsions, and on transparent surfaces. Photomicrographic records are possible and stereophotomicrographs reveal detail in three dimensions. When stained or pigmented, speci-

mens do not have high contrast, it is possible to add phase contrast of greater visibility. All four types of Spencer diffraction plates have proved of use in microscopy. Replicas of Formvar, acetate, or silica surfaces may be examined with the phase microscope which opens a new field for investigation. Photomicrograph lantern slides were shown of typical applications including living unstained epithelial cells, bacteria, fungi, protozoa, and spermatozoa; unstained tissues, chromosomes, and malaria parasites; stained chromosomes, urine casts, emulsions, wool, rayon, paper, and replicas of steel surfaces. (*Author's abstract.*)

W. R. DURYEE, Department of Terrestrial Magnetism: *A film on the mechanism of cell division.*—The paper consisted essentially of the showing of a film prepared by K. Michel of the Zeiss Co. using phase contrast lenses and time-lapse photography.

The material photographed consisted of living spermatocytes of the grasshopper *Psophus stridulus* Linnaeus isolated in a physiological salt solution. Since time lapse photography was used, processes lasting over 5 to 15 hours were reviewed in a few minutes. In addition the phase contrast lenses brought out many details, relationships, and structural contrast that the human eye unaided could not see in normally transparent cells.

Major sequences in the film were, first, *prophase* changes in the nucleus. Chromosomes were visible shortening and thickening in their colloidal matrix. Arrangement of chromosomes on the spindles was followed by grouping of mitochondria in the mid-cytoplasm, next in the *metaphase* details of spindle lateral spread preceded actual elongation. Thirdly, separation of the chromosomes and other cytoplasmic movements during *anaphase* were shown. Final stages of cytoplasmic fission and *telophase* reconstitution of the daughter nuclei were clearly photographed.

A remarkable sequence showed continual elongation of spindle substance even after each cell had divided. Concomitant sol-gel reversals of the polar surfaces were evident. New details of spermatocyte transformation into the early spermatic concluded the picture.

The film has been adopted by the Surgeon General's office as a medical technicians' training film and was shown through the courtesy of the War Department. (*Author's abstract.*)

1282d Meeting

This was a joint meeting with the Washington Academy of Sciences, held in the auditorium of the Cosmos Club, April 17, 1947.

Program: P. W. BRIDGMAN, Professor of Physics in Harvard University.—*High pressures and their effects.*

1283d Meeting

The 1283d meeting was held in the auditorium of the Cosmos Club, April 26, 1947, President MOHLER presiding.

Program: PAUL F. WACKER, National Bureau of Standards: *Heat capacities of gases.*—Experimental heat capacity data for gases are useful both for the calculations of heat requirements in industrial operations and in checking statistical calculations of heat capacity, heat content, entropy, and free energy of complicated molecules. These calculations are made for extremely wide temperature ranges and permit calculations of yields of reactions as well as heat requirements.

Heat leaks were made negligible by the use of thermostated radiation shields and a carefully designed calorimeter. This absence of heat leaks made high precision possible and reduced consistent errors to very small values. The working time was also reduced, since ordinarily it is necessary to make measurements as a function of flow rate in order to correct for heat leak. As a check for consistent errors, the heat capacity of oxygen was measured and compared with highly accurate values calculated statistically from spectroscopic data. The values at $-30°C$ and $+90°C$ differed from the spectroscopic data by 0.06 percent and 0.10 percent, respectively, while the experimental value at $+40°C$ did not differ from the spectroscopic data by a significant amount. Consideration of the data obtained for oxygen and the known sources of error indicates that the measurements with the apparatus have a probable error of 0.06 percent or 0.07 percent. (*Author's abstract.*)

W. H. AVERY, Johns Hopkins Applied Physics Laboratory: *Infrared spectra at low temperatures.*—Difficulties caused by overlapping of the infrared absorption bands restrict the application of these spectra to the analysis of complex hydrocarbon mixtures. Theoretical considerations suggested that these difficulties

might be minimized by observing the spectra at low temperatures, since the width of the absorption bands is predicted to be proportional to the square root of the absolute temperature. Using a cell with a reflecting bottom surface which could be immersed in liquid hydrogen, upon which films were condensed, spectra were obtained of a number of saturated hydrocarbons. The spectra were found to show the predicted narrowing of the absorption bands and a striking decrease in overlapping of the bands. Quantitative application of the method was interfered with, however, because of the scattering due to small crystals of the condensed hydrocarbons. A change from the gaseous to solid phase did not produce any significant shifts in the position of the bands of saturated hydrocarbons, but there were some indications that overtone and combination bands were changed in intensity by the condensation. The use of liquid helium was suggested for a further improvement in resolution of the spectra. A theoretical analysis of probability of the overlapping bands in complex mixtures showed that the use of low temperatures might be expected to increase tremendously the number of mixtures susceptible to infrared analysis. (*Author's abstract.*)

1284th Meeting

The 1284th meeting was held in the auditorium of the Cosmos Club, May 10, 1947, President MOHLER presiding.

Program: D. H. MENZEL, Harvard College Observatory: *Problems of the sun.*—Our rapidly accumulating observational data on the sun have served to focus our attention on the many unsolved problems of the solar atmosphere. Although the surface layers appear to possess a temperature of about 6,000°C, the temperature and excitation rise rapidly in the higher levels. In the upper chromosphere and prominences, the temperatures range from 10,000°C to 25,000°C. In the solar corona, temperatures may attain values in excess of a million degrees. There are many additional problems such as the support of the prominences and chromospheric layers and the explanation of the gases in the solar atmosphere. Thus far, we have no completely satisfactory theory of any of these phenomena.

The solar observations made regularly at the High Altitude Observatory of the Harvard University and the University of Colorado, located at Climax, Colo., have provided the astrophysicists with new indices of solar activity. Even though we do not yet understand the basic physical processes, we realize that marked changes in the output of solar ultraviolet radiation accompany the prominences and coronal disturbances. These ultraviolet variations, in turn, affect the ionosphere, the earth's magnetic field, and the luminosity of the night sky. There is also a high probability that there may be a relationship between solar activity and terrestrial weather. The ozone layer of the earth's atmosphere acts as a medium to transmit solar impulses from the upper to the lower atmospheric levels.

Study of the sun, for the above-mentioned practical reasons, assumes an increasingly important place in science. Accurate forecasting of radio-propagation conditions or of weather in general would possess immense economic value. For example, if only we could tell the farmer that the next growing season will be hot or cold, wet or dry, late or early, many losses would be avoided.

For the long-range view, study of solar radiation has additional practical applications. No natural process is now replacing the stock of oil and coal, produced over geological ages. An understanding of the sun and solar processes will help us to utilize more effectively the solar radiation, upon which we shall eventually have to depend for heat and power. (*Author's abstract.*)

1285th Meeting

The 1285th meeting was held in the auditorium of the Cosmos Club, May 24, 1947, President MOHLER presiding.

Program: A. E. RUARK, Johns Hopkins Applied Physics Laboratory: *Behavior of particles in scattering and absorbing media.*

A. J. SHNEIDEROV presented an informal communication regarding gravitation.

The president announced the election of the following Committee on Communications for the season 1947–48: G. B. SABINE, *chairman*, R. C. HERMAN, and THOMAS CARROLL.

WALTER L. CHENEY, *Recording Secretary.*

CONTENTS

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 38 FEBRUARY 15, 1948 No. 2

PHYSICS.—*The measurement of high voltage.*[1] F. M. DEFANDORF, National Bureau of Standards.

INTRODUCTION

This paper presents an outline of the basic principles used in measuring high voltages. It appraises the accuracies attained by some of the methods and devices currently in use, rather than attempts to give historical credit for discovery and invention, although numerous references are cited which should prove useful to one interested in tracing such matters. The expression "high voltage," in the title of this paper, will be construed to include voltages of the order of 100 kilovolts and higher. It will be convenient to leave out of consideration many voltage measuring devices useful in the neighborhood of 100 kv and lower but of doubtful value in extending the range to much higher voltage by increasing the proportions of the device. This demarcation also serves to exclude from this discussion the methods of measurement of voltage at extremely high frequencies because voltages of this magnitude are nonexistent at those frequencies. The first portion of this paper will logically be devoted to a discussion of certain reliable methods of extension in range from low voltage standards.

It is proper to ask why one should be interested in the accurate measurement of high voltage. One must be interested because many phenomena depend on voltage. For instance, the hardness limit of X-radiation emitted by an X-ray tube depends upon the maximum value of the voltage across the tube including the ripple or any superposed surge. Similarly the sparkover voltage of a sphere gap and the a-c flashover values for a string of line insulators depend upon the crest of the alternating voltage applied to the gap or string. In those cases it is the maximum voltage arising from the combination of all voltage components in which we are interested. In the surge-voltage breakdown test of a lightning arrester it is the crest of the applied surge that is fundamental, although the form of the surge, if it rises very rapidly, may be important. This is because with surges of increasingly steep wave front the crest breakdown voltage actually increases because it requires an appreciable though short time to establish the mechanism of breakdown. On the other hand, in the commercial sale of energy it is the effective value of the voltage and its phase with respect to the current that is important. Thus the measurement of high voltage in the cases just mentioned presupposes some knowledge not only of the magnitude of voltage, say from thousands to several millions of volts, but also a knowledge of the variation of the voltage with time. This variation of voltage with time, which may have the form of a wave, pulse, ripple, or some other shape in no way resembling our everyday conception of a wave, is called wave form.

From the foregoing discussion one may conclude that the significant characteristics of voltage to be measured, illustrated in Fig. 1, may be listed as:

1. Direct voltage (d-c voltage).
2. Effective alternating voltage (effective a-c voltage).
3. Average alternating voltage (average a-c voltage).
4. Crest or maximum voltage of a rippled d-c-, alternating-, or surge-voltage.
5. The wave form of a surge- or alternating-voltage.

[1] Address of the Retiring President of the Philosophical Society of Washington, delivered at the 1274th meeting of the Society on January 4, 1947. Received July 28, 1947.

For the measurement of voltage it has been found convenient to adopt as a primary standard, the voltage of the standard cell. The unsaturated standard cell, the voltage of which is approximately 1.0186 ± volts, is almost universally used as a laboratory reference standard for voltage measurements. When kept in a thermostated enclosure and used under favorable conditions, it exhibits a remarkable constancy of voltage. The small differences that may arise in a thermostated group of cells from year to year are of the order of microvolts. Unfortunately, similar electrochemical devices having 100, 1,000, or 1,000,000 times the voltage of a standard cell do not exist. Therefore, in the usual measurement of higher voltages, it has been necessary to develop devices which ultimately refer back to the standard cell.

Resistance methods of extending the range of voltage upward from the value of the voltage of the standard cell make use of the fact that by selecting suitable alloys and heat treating them properly resistors can be constructed to have a resistance, or a ratio of resistance, that remains constant to within a few parts in 100,000 over a satisfactory temperature range. The use of a potentiometer or of a tap resistor (volt box) is the simplest method for extending the range of measurements of direct voltages by reference to the standard cell. If r is the resistance from one end to the tap point and R is the total resistance including r, then the voltage e across r can be measured with reference to a standard cell by using a potentiometer and the voltage V across R is then $V = e \cdot R/r$.

Although this simple resistance method is adequate for small steady direct voltages it requires modification for the precise measurement of the high varying direct-, alternating-, surge-, and pulse-voltages that one encounters in practice. The manner in which the voltage at any instant varies with the time is a fundamental factor in the problem of measurement. It is necessary to express alternating voltage in terms of direct voltage which can be evaluated by reference to the standard cell. Instruments designed to read the same on the effective value of alternating voltage as on direct voltage are called "transfer instruments." As transfer instruments, electrostatic instruments (*1*) are favored in Great Britain,

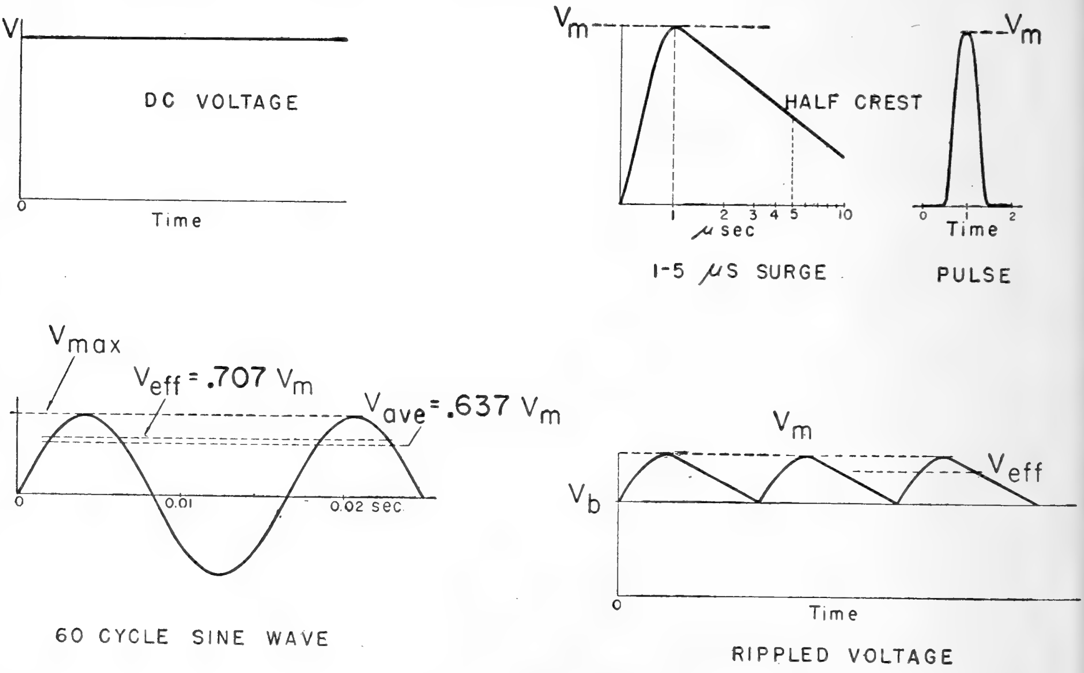

Fig. 1.—Wave forms.

while electrodynamic instruments (*2*) find favor in this country. An electrostatic voltmeter, for instance, should give the same indication for a direct voltage V as it does in the case of an alternating voltage of pure sine-wave form for which the crest or maximum voltage $V_m = \sqrt{2}\ V$.

If rectified alternating voltage is applied to a direct current voltmeter the instrument will read the average value of voltage applied to it, i.e., $V_{ave} = (1/t)\int_o^t vdt$.

If, however, completely rectified alternating voltage is applied to a good electrostatic voltmeter the voltmeter will read the crest voltage. Crest voltage can also be determined from the length of a spark gap across which it will just cause a discharge, or it can be readily evaluated from the wave form determined by use of a calibrated oscillograph.

A more detailed knowledge of the variation of the voltage with time such as is given by an oscillograph becomes of special interest in the case of pulse and surge voltages. Thus it would seem appropriate to appraise the value of the several devices used in the delineation of wave form, and to mention each type under the particular voltage divider or device with which it is generally associated.

A consideration of high-voltage measuring devices appears to lend itself better for discussion under a classification of methods of measurement or types of devices rather than under the classification of characteristics of voltage previously outlined. The devices which are useful in measuring high voltage may be conveniently classified as to type by considering whether the method of measurement employs:

1. A high series impedance with a low-impedance instrument to indicate current through the impedance.
2. A potential divider in which a fraction of the total voltage is measured across tap points of the impedance.
3. A voltage transformer that permits measurement of a low voltage having a direct ratio to the high voltage.
4. A generating voltmeter in which a voltage proportional to the field intensity in the region of the instrument is indicated.
5. A spark discharge in which the length of the spark gives a measure of the voltage.
6. The cooling effect of an "electric wind" as in the ionic wind voltmeter.
7. Force arising from the attraction or repulsion of electrostatic charges on electrodes.
8. The deflection of a stream of charged particles by means of a known field, either electrostatic or magnetic, after their acceleration in vacuo by the voltage to be measured.

The devices used in measuring high voltage will be considered in accordance with the above classification and in the order listed.

SERIES IMPEDANCE METHOD

The simplest method of measuring high voltage would appear to be to connect a high impedance in series with a sufficiently sensitive current measuring instrument having a negligible impedance compared to the value of the high series impedance, Z. Values of the indicated current, i, would then give the high voltage, $V = iZ$. The impedance Z may, of course, be primarily resistive, inductive, or capacitive or combinations of these elements.

Series resistors.—This basically simple method has been widely used in nuclear disintegration work for direct voltage measurements, wherein the impedance Z is built of many high resistance units in series (diagram at A in Fig. 2), care being taken to insure that the current entering at the high voltage end of the resistor is the same as that leaving through the deflecting instrument at the low voltage end. For reliable measurements it is necessary to be sure that the electrical leakage across insulating supports of the resistor and from section to section is negligible and that there is negligible corona current from the units. Changes arising from self-heating must be made negligibly small or must be allowed for. The design of such a series resistor should be substantially the same as for the potential divider type to be discussed later in detail.

Series reactors.—For alternating voltage measurements, series reactors have been used as the series impedance (*3*). They have the drawback, however, of requiring iron cores at lower frequencies if the inductive reactance is to be made large in comparison with the resistance of the windings. Stray and distributed capacitance effects raise additional objections so that series reactors have been little used in high voltage measurements.

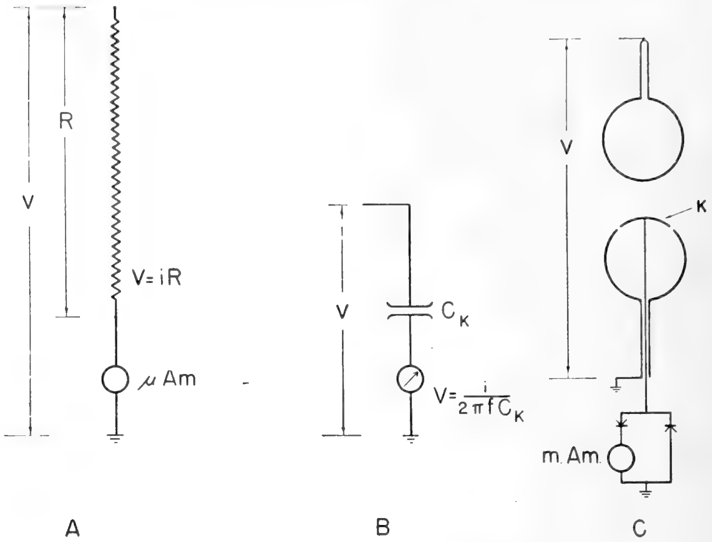

Fig. 2.—Diagrams of series impedors.

Series capacitors.—For the measurement of high alternating voltage, capacitance may be used in series with the low voltage indicating instrument, as indicated at B and C in Fig. 2. The capacitor, which must be relatively free from losses, corona, and brush discharges, magnifies the effect of harmonics present in the voltage wave form unless the low voltage instrument is of the capacitance type.[2] However, if harmonics are present, corrections can be applied. This device in a form for measuring high-crest voltage was originally described by Chubb (*4*) who employed the two spheres of a sphere gap as the capacitor, the lower and grounded sphere being insulated to permit rectification of the capacitance current to it. Such devices (*5, 6, 7*) appear to have been used more generally in foreign laboratories than in this country. The arrangement is indicated at C in Fig. 2. Haefely & Co. patented (*7*) such a device which employs as one electrode of the high-voltage capacitor, a large insulated circular segment of the lower sphere. The remainder of the sphere serves as the grounded guard for this segmental electrode. The upper sphere serves as the high-voltage electrode.

These devices generally permit only a rough computation of capacitance and therefore need to be calibrated against some other voltage standard, but they have the advantage over the sphere spark gap of giving a continuous rather than transient indication of voltage when used with an electrostatic voltmeter or rectifier-milliammeter combination. Although the early device of Chubb gave the crest value[3] of voltage, later similar arrangements (*9*) were devised that permit the determination of both crest- and effective-values of voltage, and when supplemented with a cathode ray oscillograph or synchronous commutator (*8*) give the high voltage wave form as well. For relative measurements, this series capacitance method should be good to a few tenths of one percent.

POTENTIAL DIVIDERS

The potential divider is essentially some form of impedance with one or more tap points permitting the measurement of the voltage drop between tap points by a method which preferably does not change appreciably the current flowing through the divider. The potential divider is connected across the voltage to be measured. The

[2] Here the combination serves as a potential divider and a low voltage electrostatic voltmeter across a large capacitance gives effective values of voltage independent of wave form.

[3] Except in the case of alternating voltages of unusual wave form in which there are several maxima (*8*).

F. M. Defandorf
President of the Philosophical Society of Washington, 1946

value of voltage measured between taps, when multiplied by the ratio of the value of the total impedance to that of the tapped section then gives the value of voltage across the total impedance. Potential dividers are commonly constructed of sections of resistance, of resistance shunted by capacitance, or of capacitance. Types of each of these will be described.

Corona shielded resistor.—For a resistive divider one may use n resistors, each of resistance r, all exactly alike (or nearly so), connected in series, or one resistor $(n-1)$ times as large as the smaller one connected in series with it, and across which the voltage drop is measured. For use at higher voltages, both the electrical and mechanical designs of the physical device require care. Improvements in his earlier designs (*10*) have been incorporated by L. S. Taylor in a resistor, not yet described, which is in use in the measurement of the high rectified voltage supply for a 1.4-million-volt X-ray tube in the X-ray Laboratory of the National Bureau of Standards. As seen in Fig. 3, the column at the left side contains the corona-shielded resistor, which is installed immediately adjacent to the column of 10 large cascaded-rectifier tanks, each of which at maximum voltage contributes 140 kv to the total voltage of 1.4 million. This arrangement provides double shielding. The external system seen in Fig. 3 has tubular connections from the spun-metal corona shields to each section of the cascaded supply. The internal resistor assembly, also separately corona shielded, is thoroughly insulated from this outer system. Thus the currents required by the outer shields are supplied as a sectionalized direct load on the supply independently of the measuring circuit. This outer shield therefore takes care of current flow arising from external ionization, migratory dust particles, and minor surface discharges as well as surface leakage across the insulating columnar supports, and relieves the internal resistor of the resulting irregularly varying effects. In addition, the separate outer shields provide mutual field grading and the large top shield is effective in shaping the general electrostatic field. The internal resistor assembly is sectionalized, each section consisting of uniformly spaced wire-wound resistors located between toroidally shaped corona shields, which are electrically connected to the end of each group of resistors. Isolantite insulation is used for supporting the resistors and the uniformly spaced corona shields. The shields were constructed of smooth copper-tubing of circular section in order to provide satisfactory field grading along the resistor and thus to insure freedom from corona discharge currents at the highest intended operating voltage. The design provides for adequate insulation, mechanical support, and centering of this

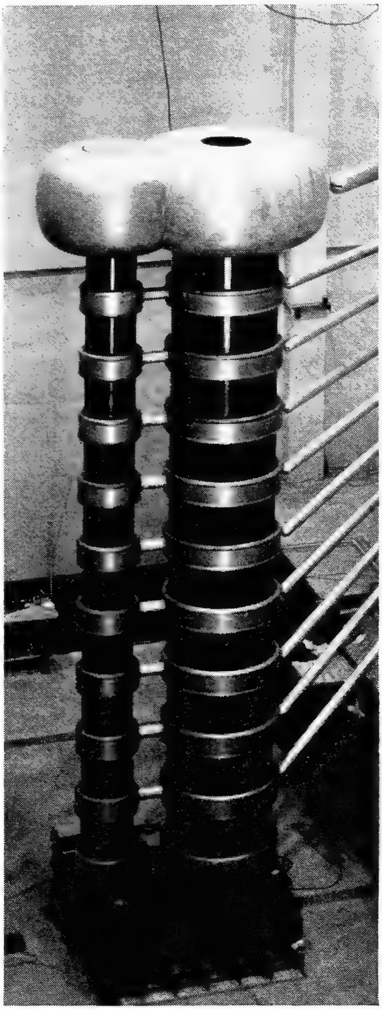

FIG. 3.—1.4-million-volt rectifier column with shielded resistor column on left side.

column inside the outer corona shield. Each section was adjusted and thoroughly tested at rated voltage before assembly and subsequent measurements of individual sections show their resistance to be practically free from drift. These precautions were taken to make sure that the current throughout the resistor will be the same as at its low voltage end where measurement of the current is made; i.e., in order that the high voltage, V, being measured is equal to nri where nr is the total resistance of the stack of n shielded resistors. Actually the current, i, is often determined by adding a small resistor, r_o, and measuring $v = ir_o$ by means of a potentiometer.

Manganin wire-wound resistors and a relatively large current of 1 milliampere were chosen as design values in order to minimize parasitic effects of leakage, absorption, and corona currents, and thus to insure a resistor that would permit measurements to 0.1 percent or better. A current of 1 milliampere corresponds to a load of 1.4 kilowatts, so that the resistor was designed to dissipate a corresponding amount of heat. Carbon or the so-called "metallized" radio-type resistors have a much higher temperature coefficient and are in general less stable than wire-wound resistors. Considerable care must therefore be taken in their use to insure freedom from thermal and voltage effects. Although reduction in self-heating and in energy loss in such resistors may be secured by reducing the current say to 0.1 milliampere, the effects of leakage currents become relatively more important and may contribute to some extent in reducing the attainable accuracy to the order of 0.5 percent.

Still another consideration that should not be overlooked is the shunting effect on the resistance of the capacitance of the shields. In the case of a resistor of the high resistance type, sudden surges are easily transmitted through the shunting capacitances so that the measuring instrument, which must be correspondingly more sensitive, requires increased surge-protection. Thus there are drawbacks to either increasing the current in the measuring resistor to values greatly exceeding one milliampere because of increased energy loss, or decreasing it to values much below 0.05 milliampere because of the instability of the resistance insulation, and of other troubles. For much of the pioneering nuclear disintegration work (*11*) carbon resistors available in units of much higher resistance per unit length than the wire-wound type have proved both economical and useful.

It should be observed that the relatively high shunting capacitance of the corona shields of this type of resistor limits its usefulness as a resistor for alternating current measurements.

Capacitance shielded and guarded resistors for alternating current.—The resistor divider, in high favor for the measurement of direct voltage, has certain specific defects in addition to its relatively large consumption of power. It necessarily has residual inductance and stray capacitance associated with its resistance. As shown at A in Fig. 4, each section $r_1 \cdots r_n$ may be considered as having at its terminals a lumped shunting capacitance of value $C_1 \cdots C_n$, and between its upper terminal and ground a capacitance $C_a \cdots C_m$. If the value of capacitive reactance $1/2\pi f C_1$ is $\gg r_1$ and $1/2\pi f C_a \gg nr_1$ and if the impedance used in the measuring circuit shunting r_n is $\gg r_n$, the voltage division by resistance will be trustworthy. As a result of the increase in shunting effect of the stray capacitances with frequency, these inequalities grow less until the division of the applied voltage is no longer proportional to resistance.

The shielded a-c resistor (*12*) minimizes the effects of the unavoidable ground capacitances at the cost of additional energy dissipation, by employing a second or guard resistor in parallel with the first or "working" resistor. This guard resistor is so connected to the shields that it supplies current to the ground capacitances that otherwise would have to be charged through and along portions of the working resistor. In an a-c shielded resistor the working, or shielded resistor, is composed of sections of value r each contained within a metal shield or box as indicated at B in Fig. 4. Each shield is maintained at a potential corresponding to the midpoint of its enclosed resistor by connecting it to a tap point on the proper section R_n of the guard

resistor. Thus this arrangement makes the value of each shunting capacitance definite and supplies the ground capacitance current from the guard circuit. This is accomplished at the cost of a slight increase in the shunting capacitance of the individual resistors because of the capacitance to the shield in which they are located, since one end of the enclosed resistor is above and the other below the potential of the shield. However, because the potential difference across the capacitance of either end of the resistor element to its shield is only one-half the voltage drop in this section of resistance r, the shunting effect need not be excessive at low frequencies, say 25 or 60 cycles. Such a resistor, composed of about 25 shielded sections, is used in a voltage transformer testing setup for phase-angle measurements and ratio measurements to 0.01 percent at the National Bureau of Standards. This resistor is rated at 0.05 amperes in each of the two (working and guard) 500,000-ohm circuits. In this device, which at 25 kv absorbs 2.5 kw, the individual sections of the working resistor are enclosed in metal shield boxes, which are filled with oil in order to improve thermal characteristics. This resistor is arranged in tiers, each tier consisting of four working resistor boxes with corresponding sections of the guard resistor supported on a mahogany framework. Tiers are assembled one above the other by means of porcelain bus-type insulators, which serve to provide additional insulation and to permit bolting together of the resistor-supporting frameworks to form a mechanically stable assembly. Each box contains 20 flat mica cards wound unifilarly with manganin wire. It is not feasible to extend the range of a-c shielded resistors and retain the same order of accuracy (0.01 percent) by this procedure much above 30 kv because of the effects of the capacitances which shunt the guard resistances. The resulting error increases as the fourth power of the voltage.

An a-c shielded resistor of this type is also satisfactory for use as a series resistor in conjunction with an indicating voltmeter or sensitive oscillograph. It may be used equally well on direct current but would ordinarily not be used because its

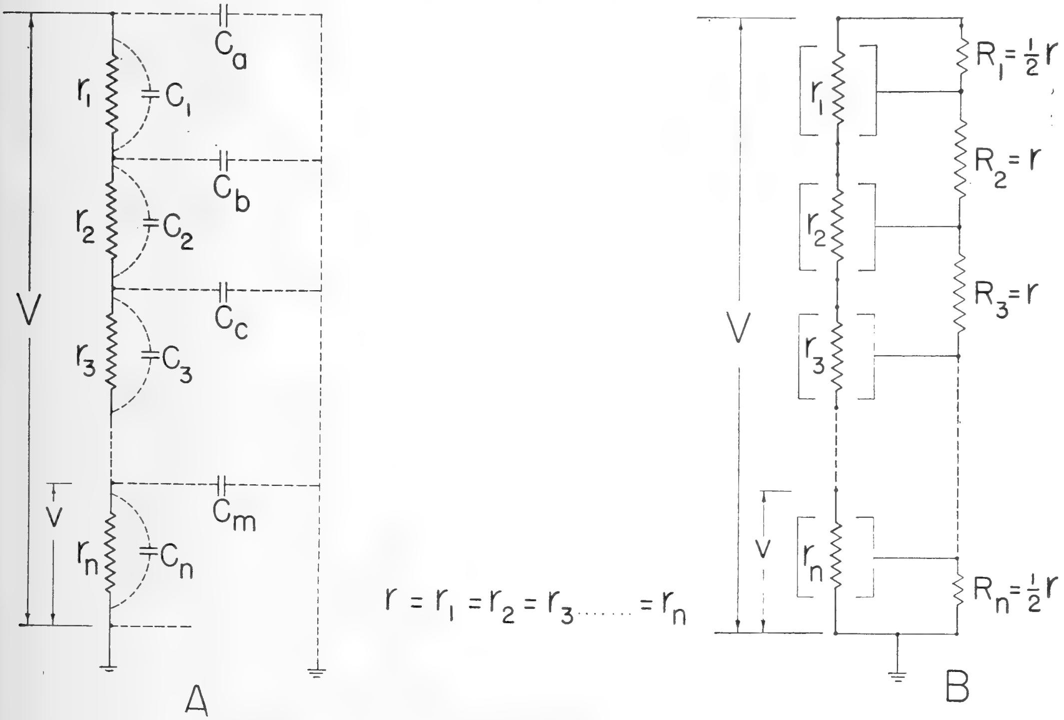

FIG. 4.—A-C shielded resistor.

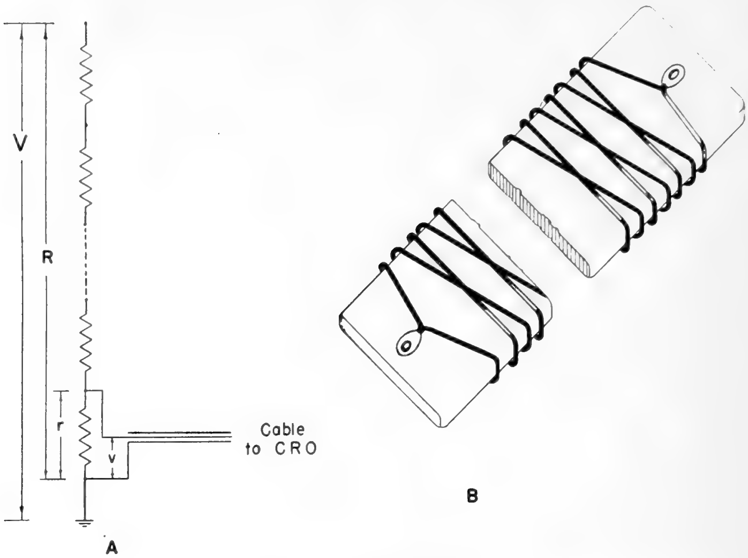

Fig. 5.—Surge resistor.

load on the source is greater than that for the simpler corona shielded resistor.

Weller (*13*) devised a shielded a-c resistor for use in transformer testing up to 132 kv in which the shield current was supplied by auto-transformers rated at 75 kva, instead of by a tapped resistor.

Surge resistors.—In surge voltage testing equipment used for studies of surge effects on electric power and transmission equipment, the fundamental component of voltage in a $1\frac{1}{2}\times 40$ microsecond wave[4] is of the order of 10^5 cycles per second. Hence components as high in frequency as 10^7 cycles per second are of significance in fixing the wave form. The cathode ray oscillograph used to delineate such surge wave forms in conjunction with a potential-dividing resistor is generally located at some distance from the resistor and main discharge circuit in order to avoid induction effects from the large surge currents. Fig. 5 indicates the common method used for connecting the resistor tap point through a coaxial cable to the deflecting plates of the oscillograph. The resistor is composed of a series of resistance cards. Each card has two similar windings wound in opposite directions and connected in parallel to reduce inductance. The cable connection to the cathode ray oscillograph has a surge impedance usually of the order of 50 ohms, whereas the full-scale sensitivity of the cathode ray oscillograph is of the order of 2,000 volts for a cold cathode-type and 200 volts for a hot cathode-type cathode-ray oscillograph. Thus for full-scale deflection the currents to a cable considered as a resistance would be of the order of 40 or 4 amperes, respectively.

Resistance dividers for high-voltage surge measurements are not provided with corona shields because they would add excessive stray capacitance but are often so located adjacent to the surge generator itself that some degree of shielding and field grading along the divider is secured. Since a resistor for a 2,000,000-volt surge measurement must be at least 700 cm. long to provide adequate longitudinal insulations and avoid flashover troubles in air, its distributed and stray capacitances introduce disturbing effects unless the resistance is held proportionately low. Thus a divider resistor for a 2,000,000-volt surge may have a resistance as low as 5,000 ohms and, if wire-wound, the wire must be of sufficient diameter to carry high momentary currents without damage. As a rule, accuracies of the order of one percent are all that are required. If it is desired to study surge com-

[4] I.e., one that rises to crest in $1\frac{1}{2}$ microseconds and falls again to one-half crest value in 40 microseconds.

ponents of the order of 10^8 or 10^9 cycles per second the residual inductance of each element and the distributed and particularly the non-uniform stray capacitance effects, assume especial significance in surge resistor dividers. For those frequencies, supplementary capacitance elements *(14)* may be added to the resistance elements of the divider in such a manner as to make uniform the capacitance shunting effect on each element and thus insure proper division of the surge voltage and its correct delineation by the oscillograph. The present interest in better voltage measurements of surge wavefronts of duration less than one microsecond should lead to improved designs of surge-voltage resistor dividers.

The cathode ray oscillograph plays such an important role in the field of surge-voltage (and surge-current) measurements that its contribution should be mentioned at this point. Although its value for use at lower frequencies should not be underestimated, it stands alone in versatility for use in high-frequency, surge, and pulse measurements. It owes this versatility to the small inertia of its electron beam, which serves at the same time as the moving element and pointer. The cathode-ray oscillograph, with a suitable sweep circuit, amplifiers, shunts, and potential dividers, has been developed into one of the most useful pieces of electrical laboratory equipment and covers a range from a few cycles per second to frequencies of millions of cycles per second. Developments in electron optics and of new phosphors are constantly enlarging the place of the cathode-ray oscillograph as a useful precision device in spite of the complication of its accessory equipment. In the future an order of accuracy better than 1 percent may be expected. For most measurements, and especially those of high voltage surges, its high effective impedance results from the low capacitance between its deflection plates. The energy loss, arising largely from stray ions and electrons within the tube, is so small as to be of little concern. Thus in the visual or photographic delineation of wave, surge, and pulse shape the starting point now seems to be a calibrated cathode-ray oscillograph except in very special instances in the low frequency range where a higher order of accuracy is required.

Capacitor dividers.—Because residual inductance and residual capacitance effects in a resistance divider are unavoidable, not only in the resistance elements themselves but also in their electrical connections, it is natural to turn to the use of capacitance elements for alternating voltage division. The capacitance divider generally consists of a single high-voltage guarded-electrode capacitor in series with a low-voltage capacitor of very much higher capacitance. The

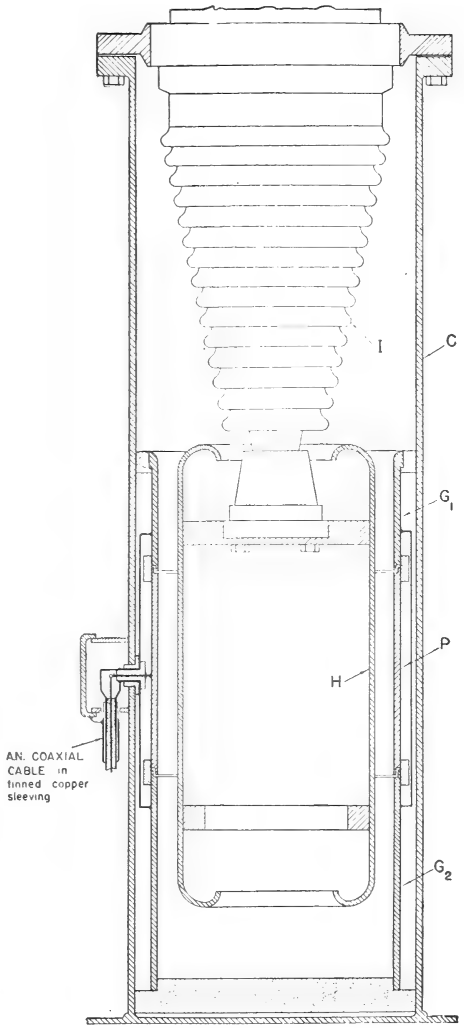

FIG. 6.—Compressed-gas capacitor. Diagram of Bousman and Ten Broeck capacitor altered to include complete shielding of the working electrode.

residual inductance effects in capacitors are minimized by properly shaping their sizable conducting parts. The residual resistance effects are minimized (1) by using high grade solid insulation for the electrode supports in order to keep electrical leakage through and across the surface of the insulation low; (2) by using free-air or compressed gases (*15, 16*) as the dielectric because of their low dielectric loss; and (3) by using electrodes with well-rounded contours and smooth surfaces to insure freedom from corona discharge. It is customary to support the guard electrode on its own insulation opposite the high-voltage electrode and in turn to support the guarded low-voltage electrode on the guard. The insulation between the guard and the guarded electrode is arranged to lie outside the high electrostatic field so that dielectric losses as well as surface and volume leakage to the working capacitance are minimized.

The range of various types in free air is limited by the breakdown voltage of air to a practical value of about 15,000 v/cm gradient. Churcher (*17*) has described a capacitor for use at 300 kv, cylindrical in form, with an over-all diameter of 2 meters and a height of 7 meters. This unit is to some extent an absolute standard as it permits computation of its capacitance from dimensions measured under normal working conditions. To that extent it is preferable to a smaller compressed gas type (*16*) shown in Fig. 6[5] for use up to 300 kv, having an outside diameter of less than 1 meter and height over the bushing of 3 meters, and a shielded capacitance to the high-voltage electrode of 50 micromicrofarads. However, when the space available is limited, the compressed-gas equipment may be built to occupy about one-fourth the space of a free air unit of the same rating. The one advantage, which may be in part psychological, of constructing a capacitor whose capacitance can be calculated from its dimensions lies in the care and precision demanded in its design and manufacture.

[5] In this figure the original design of Bousman and Ten Broeck has been modified to show complete shielding of the outer guarded cylindrical section by the guard.

A rather recent and desirable circuit arrangement using a compressed-gas shielded capacitor for testing potential transformers is described by Bousman and Ten Broeck (*16*). Their circuit arrangement is similar to a Schering bridge, i.e., a bridge in which the A and X arms are capacitances instead of resistances. The difference lies primarily in the mode of supplying the voltage to the bridge, the high-voltage arm (A) being supplied by connection to the ungrounded end of the high-voltage winding of the transformer, and the low-voltage arm (X) being connected to the ungrounded end of the low-voltage winding. Thus if this bridge is balanced when supplying power to one winding of the transformer, one may determine from the settings of the bridge arms both the voltage ratio and phase angle of the transformer. A simple reconnection of the bridge arms to a suitable supply permits quickly checking the constancy of the bridge arm components before and after ratio and phase angle measurements. Thus in this bridge reliance for the ratio measurement is placed primarily not on capacitances but on the constancy of resistance coils which are more suitable as reference standards because of their stability, while the phase angles are based on the air capacitors. An extension in range to higher voltages might logically follow the arrangement of Bousman and Ten Broeck without serious reduction in the accuracy of 0.1 percent claimed for their equipment.

The subject of high-voltage wave form should also be considered in connection with capacitance dividers. Offhand, capacitance dividers would appear to be ideal for use with the cathode-ray oscillograph, as its impedance is essentially capacitive reactance. In surge measurements, however, it is usually both desirable and convenient to locate the cathode-ray oscillograph at some distance from the surge circuit in order to minimize inductive effects. This involves the use of a fairly long high-quality cable (preferably coaxial) connecting the divider to the oscillograph so that the surge impedance of the cable, primarily resistive, rather than the capacitive impedance of the oscillograph plates assumes the major role in the measurement

circuit. Thus, as suggested earlier, a surge resistor is to be preferred although surge capacitor dividers (*18*) have been used. For lower-frequency measurements this objection does not exist to the same extent and capacitor dividers with cathode-ray oscillographs as well as with amplifiers supplying electromagnetic oscillographs (string or loop in use up to several thousand cycles per second) have been found useful in delineating wave form with an accuracy of a few percent.

A capacitance-divider method yielding a high order of precision in delineating low-frequency wave form is due to Silsbee (*19*) who, in line with the early work of Rosa, used a point-by-point method. In his device a potentiometric balance by means of a quadrant electrometer is obtained across the low voltage portion of a capacitance potential divider for as many points in a repeated voltage wave as may be desired, thus permitting the evaluation of crest-, average-, and effective-values of the wave form. This method requires a synchronously driven contactor which may be set accurately for each balance point selected for delineating the wave. The accuracy of measurement is very high and appears to be limited primarily by the steadiness of the alternating voltage source, say to a few parts in ten thousand.

TRANSFORMER METHODS

Voltage transformer.—The method of measuring high alternating voltage in common use in the United States employs a step-down transformer termed a voltage or "potential" transformer by the manufacturer in order to designate its intended use in voltage and power measurement. The high-voltage winding is connected across the terminals of the voltage source to be measured, a voltmeter is connected across the low-voltage winding and its reading is multiplied by the ratio of transformation to obtain the value of the high voltage. The ratio of voltage of the high-voltage winding to that of the low-voltage winding of a well-designed transformer remains nearly constant over a wide range of voltage. The measured values of ratio of well-built transformers kept under normal laboratory conditions have been found to remain remarkably constant over long periods of time, variations in ratio requiring for their detection measurements having an accuracy of the order of 0.01 percent. Departures from nominal ratio have been determined by resistance bridge methods (*20*) up to 30 kv with a precision of 0.01 percent and by capacitance bridge methods up to 132 kv with a precision of 0.1 percent or better (*16*).

Where symmetrical multiple high-voltage windings are provided in a voltage transformer the following "series-parallel principle" has been found valid for extrapolating measurements of ratio factor at low voltage to permit their use at higher voltage. Within the voltage limits of a high-voltage shielded resistor or capacitor, and with the high-voltage windings in parallel, measurements of ratio factor are made to cover the voltage per coil range of the low-voltage winding. The nominal ratio for series connection is then multiplied by the measured ratio factor at the same volts per coil for the parallel connection. Reliable measurements of effective alternating voltage by this method can be made to better than 0.1 percent (*20*) and are in use up to 250 kv. The cost of transformers with such symmetrical multiple windings increases rapidly with voltage. Other less expensive and less accurate (1 percent to 0.5 percent) transforming devices such as (1) a number of small chain-connected or cascaded transformers (*21*, *22*) and (2) a high-voltage resistor (*23*), reactor (*24*), or capacitor (*25*) in series with a small transformer, have been introduced in Europe for measuring high voltage but have not met with general favor in the United States.

Supply transformer with high-voltage winding tap or with voltmeter coil.—Although the use of a voltage transformer with only an instrument connected as the burden on the low-voltage winding represents the ideal arrangement, it should be mentioned that adequately precise values of high voltage may often be deduced from voltage measurements made on the low-voltage input windings. This is particularly true if the resistance and leakage reactance of the high-voltage winding are low and the cur-

rent drawn by the load on the high-voltage winding is small. Better still, an instrument connected between ground and a tap point on the high-voltage winding (*26*) near its grounded end may serve for measuring a relatively low voltage which will be proportional to the high voltage except in so far as the voltage across the tapped section of winding is affected by distributed and stray capacitance currents which flow through it from the rest of the high-voltage winding. Fig. 7 shows three such 350 kv 60 c/s 1,000 kva transformers in the High Voltage Laboratory of the National Bureau of Standards. These units are shown connected in cascade to give 1,000,000 volts. Each unit has a high-voltage winding tap connection giving an accuracy of voltage measurement of about 2 percent at full load and correspondingly better accuracy at lighter loads. Still another arrangement consists in providing a third winding or voltmeter coil (*27*) so located relative to the low- and high-voltage windings that the magnetic flux linked by it automatically takes into account any voltage drop in the high voltage winding arising from the load connected to it. An accuracy of one-half of 1 percent at full-load leading current and better accuracy at smaller loads is claimed for a good design. These latter arrangements are not considered to be as trustworthy as the use of a separate voltage transformer.

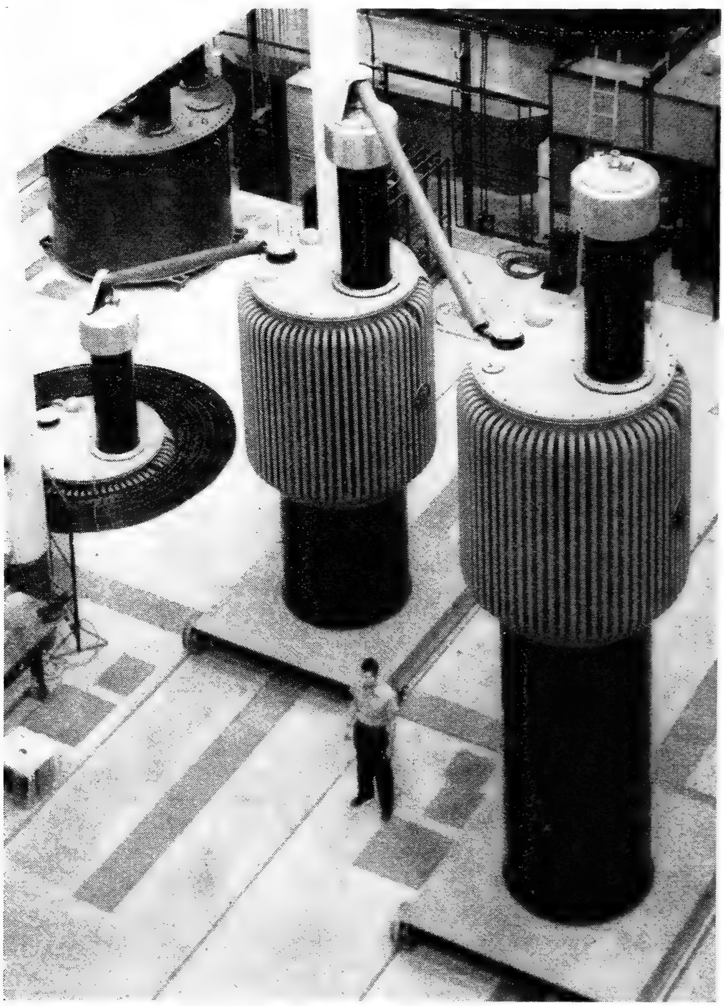

FIG. 7.—Three transformers connected in cascade to give 1,000,000 volts.

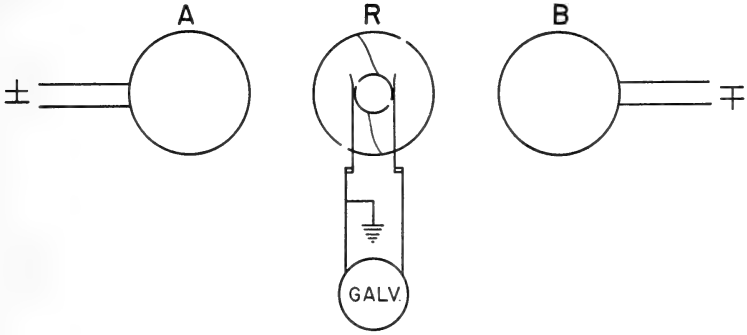

FIG. 8.—Bipolar generating voltmeter.

GENERATING VOLTMETER

The generating (rotary) voltmeter (*28*) first described by Kirkpatrick has been useful in estimating local potential gradients and as an auxiliary control device. It has been likened to a d-c generator, but instead of currents induced by moving wires in a magnetic field it employs a configuration of electrodes which permits the commutation of charges induced on plates alternately exposed to and shielded from an electrostatic field. Fig. 8 shows the diagram of a bipolar generating voltmeter. Fig. 9 shows a ceiling-mounted type designed by Behr that employs a sector disk as the rotating element.

The fundamental idea has been incorporated in many designs. Because of the necessity of alternately exposing and shielding the active plates (electrodes) the generating voltmeter appears to offer greater promise for use in relative measurements than in absolute measurements. Thus it is usually first calibrated in terms of other satisfactory low-voltage standards, prior to use at higher voltage, but it may be used in those cases not requiring a high order of accuracy and thus amenable to simplifying assumptions for the purpose of computing the high voltage from dimensions. By so shaping the high voltage electrodes that discharges and consequent space charges are avoided it may be used by extrapolation techniques to extremely high voltages both on direct and alternating voltage. Without an incorporated high-voltage electrode it is essentially a gradient measuring device. It has been useful in a study of atmospheric electric charge and field phenomena responsible for lightning (*29*), and as a voltage

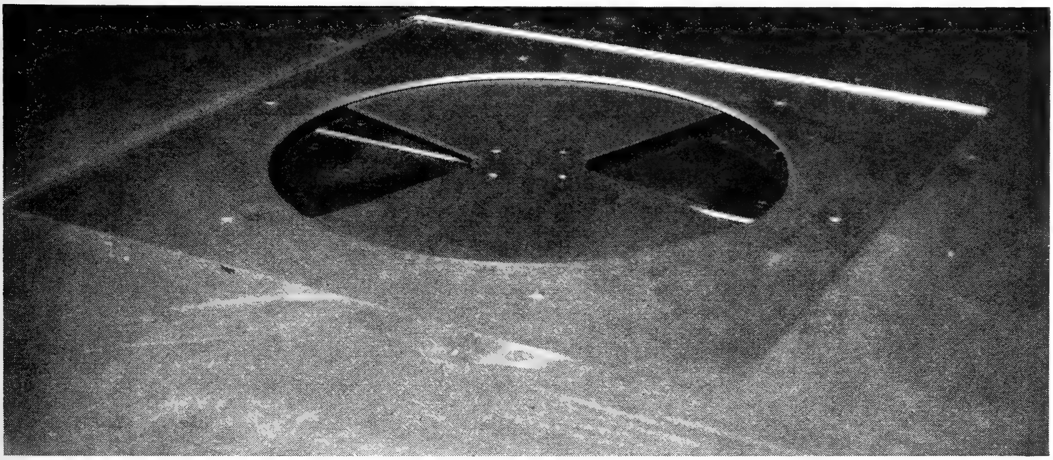

FIG. 9.—Rotating segments of Behr generating voltmeter.

measuring device associated with high-voltage generators of the Van de Graaff type.

When the generating voltmeter is used as a voltage measuring component (i.e., as an instrument for determining a value of gradient to be multiplied by a constant factor in order to obtain the total voltage difference) it is not sufficient that the fields in the immediate neighborhood of the instrument shall be below corona or discharge-forming values, but it is equally necessary that the gradients at surfaces in the neighborhood of the sample field as well as those at the high-voltage electrode be below discharge-forming values and that there be no nearby relatively large sources of air ionization or dust. The effect of dust and charged particles may indirectly produce serious distortions in high fields by being deposited and aligned on otherwise smooth polished metal surfaces so as to form the necessary points for initiating discharges and consequent space charges that would otherwise not exist. If the charge on the surface of the segments alternately exposed to the electric field is to be in definite ratio to the total field, then at no place in the field may the gradient exceed the approximate breakdown gradient, 30 kv crest/cm, in air at NPT. The practical limit is actually much lower. For instance, the value of average gradient at which self-propagating discharges occur in the case of thunderstorms appears to be about 10 kv/cm. In the case of the Brooks electrometer (*30*) discharges have been known to occur between the parallel faces of the electrometer plates when the voltage applied divided by the spacing had a value of 5 kv eff/cm. Thus in air at NPT it is doubtful that for a generating voltmeter an average value of gradient exceeding 7 kv max/cm with an upper limit of 20 kv/cm at the electrode surfaces can be employed continuously without some error in measurement arising from the above causes. Presumably this practical limit arises from the almost ever-present small particles of dust (insulating or semi-conducting) which when deposited on the surface upset the ideal condition of pointless smooth surfaces one wishes to assume after the instrument maker has done his best to produce them. With reasonable care and cleanliness in assembly, dust has not been found to be a problem in generating voltmeters operating within a pressure chamber at higher gradients (*31*).

When used with suitable precautions, the generating voltmeter offers a means of obtaining information not readily available in other ways. For instance when its commutating device is provided with a phase-shifting mechanism and the rotor is synchronously driven it provides a means of determining wave form (*32*) at high voltage with practically no load on the source being investigated. It is effective on a rippled direct voltage as well as on alternating voltage. When used for determining wave form it may be located in an undisturbed and readily accessible portion of the high voltage field. The generating voltmeter method of determining wave form should be good to a few tenths of 1 percent.

AIR SPARK-GAP BREAKDOWN

Sphere and rod gaps.—If an accuracy of the order of 3 percent in determining crest voltage is sufficient, as in the case of insulator testing, the sphere spark gap in air is useful as a crest voltage measuring device. For voltages above 17 kv spheres of 6.25 cm diameter and larger (up to 2 meter diameter for approximately 2,000,000 volts) operated under controlled conditions serve as voltage standards for electrical breakdown measurements of dielectrics (*33*). Earlier theories of breakdown of sphere gaps assumed that pure air, as well as other gases, has a definite breakdown strength or breakdown gradient at normal pressure and temperature. Paschen's law relating the length of the breakdown gap with air density permits correction for usual temperature and pressure variations. Russel, Dean, Peek, and others have given empirical relationships based in part on electrostatic field theory for both sphere and cylindrical gaps, which, although they fit well in a limited domain of pressure and temperature, are not so satisfying as relations (*34*) developed at a later date on the basis of the newer atom-physical background. The detailed work on discharges in gases by Loeb

(*35*) and his collaborators as well as much other valuable work in this field has provided a fairly satisfactory explanation of some of the scattering of breakdown values of spark gaps. Meek (*36*) suggests that in the case of the shorter gaps the electron avalanche initiated at the cathode constitutes the usual initial process whereas in the case of larger gaps the mechanism is more akin to the positive streamer discharge of lightning and originates within the gap at some distance from the electrode. For gaps of intermediate length there lies a domain in which the initiation may be of either variety and such gaps show a larger scattering of breakdown values. The probability of a free electron existing in the right location to initiate a discharge is, of course, an important factor in the scattering of the initial breakdown voltage when the time of application of voltage is extremely short. Irradiation (*37*) of small electrodes of the gap with radium or with ultraviolet light to produce photoelectrons is helpful in reducing this type of scattering but appears not to be necessary in the case of large spheres because of the much higher probability, in the larger volume of air between the spheres of the presence of an initiating ion or electron.

An idea of the effectiveness of ultraviolet irradiation in reducing scattering may be cited in the case of 12.5 cm diameter brass spheres. Irradiation of the spheres by an open carbon arc reduced the scattering of individual 60-cycle sparkover values by a factor of 5 as compared with the results obtained without irradiation. On the other hand the average values of sparkover voltage were lower by from two to five percent in the irradiated case, the amount of lowering being dependent on the intensity of radiation.

Basing his work on the detailed information now available on the mechanism of spark formation Ver Planck (*38*) appears to have successfully correlated the enormous amount of data on sphere spark gaps.

From the very nature of the spark between spheres and of corona on cylinders, voltage measurements based on sphere gaps and corona cylinders (*34*), because of their dependence on surface shape, cleanliness of the surface, and cleanliness of the air, appear to be limited to a rather low and questionable accuracy, say from 1 to 3 percent. When extreme precautions are used by following a ritual of cleansing, the use of ultraviolet irradiation of the spheres, limitation by resistance of surface pitting by the spark current, and by insuring "cleanup" of the sparking surfaces of the sphere gap through preliminary sparking, a series of 10 or more sparkover values often may be observed to agree to within ± 0.1 percent. However, this apparent high precision, equal to that of the high-grade indicating voltmeter employed as part of the equipment in making such observations, is deceptive. Painstaking observations made the following day under seemingly identical conditions may agree among themselves to the same precision but their average value will almost invariably differ by several tenths of one percent, and sometimes by more than 1 percent from those made on the previous day. In spite of its low order of accuracy the sphere gap serves as a commercial standard (*33*) for high alternating- and surge-voltage measurements apparently because of its basic simplicity. In larger sizes it gives a useful measurement of the maximum value of surge voltage and essentially serves as a voltage limiter when it is used in parallel with a device undergoing voltage-withstand tests.

Simple needle gaps, as a matter of historical interest, were once accepted as alternative standard voltage measuring gaps, but as a result of the inherently high scattering of values of sparkover voltage, variation in sparkover values with changes in humidity, and large scattering in sparkover voltage when used for measuring surge voltage, they have been discarded as standards. Rod gaps (*39*) in which the electrodes are used repeatedly as contrasted with the formerly prescribed use of new #00 needles for each sparkover of the needle gap, have sparkover values which are also affected by humidity to about the same extent as the flashover of porcelain insulation and appear to have replaced needle (or point) gaps for those uses where gaps are desired for correlating the flashover voltage of insulators.

IONIC WIND VOLTMETER

The Ionic Wind Voltmeter described by Thornton, Waters, and Thompson (*40*) merits some mention because it represents a unique application of a thermal method to the measurement of high alternating voltage. Use is made of the cooling effect on a heated filament arising from "electric wind." (See Fig. 10.) The heated filament, with a suitable grounded shield, is located at a distance from the high-voltage electrode in such a position that, although in the electric field, it will always be below corona-forming voltage. Ions that may be present move back and forth as a result of the alternating electric field and in striking neutral molecules increase the general molecular motion. This results in an increase in cooling effect on the heated filament proportional to the electric field. A filament that has a high temperature coefficient of resistance is connected in one arm of a Wheatstone bridge. The bridge out-of-balance indicator is then calibrated in terms of the high voltage applied to the Ionic Wind Voltmeter. Although this device may be constructed to have good sensitivity and is useful as a control device or relay, its indications are affected by change in wave form and an accuracy of only ± 2 percent is claimed for it.

ELECTROSTATIC VOLTMETERS AND ELECTROMETERS

Electrostatic voltmeters and electrometers basically depend for their indication on a measurement of the force of attraction between charges on the movable portion of one electrode surface and charges of opposite sign on another fixed electrode surface. By arranging the movable portion of the electrode to be part of a suitable geometric surface—sphere, ellipsoid, or plane—it is possible to devise an instrument in which the voltage applied can be computed theoretically from measured dimensions and the measured force of attraction. An electrometer designed to approximate quite closely the theoretical assumptions as to the conductor shape and relative dimensions required for simple theoretical computations, and thus to permit computation of the value of applied voltage from dimensions and the resulting force, is termed an absolute electrometer. This is in contradistinction to the term electrostatic voltmeter, which signifies an instrument that may be used for relative measurements but that requires calibration by means of some other standard of voltage measurement. A number of designs of high-voltage electrostatic voltmeters (*41–51*) have been constructed. Such instruments require much less electrical energy for their operation than an electrodynamic instrument with a series resistor. Corners rounded sufficiently to avoid electric discharges, high-quality insulation, and electrode spacing adequate to prevent discharges are prerequisites in the construction of both electrostatic voltmeters and electrometers.

Electrostatic voltmeters.—With a few exceptions (*46, 47, 49*) the high voltage electrostatic voltmeters follow the pattern of the Kelvin (*52*) guard-ring electrometer by having a guard ring for the attracted disk or movable electrode while placing less emphasis on the flatness of the movable electrode. Provision is usually made for

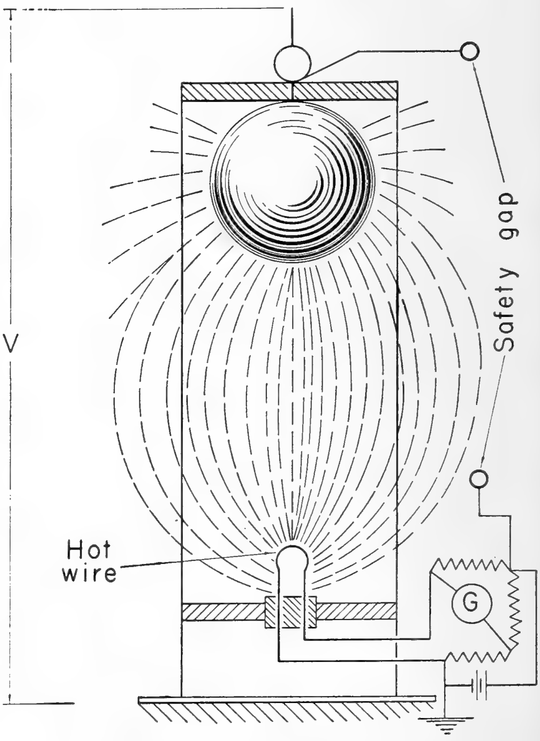

Fig. 10.—Ionic wind voltmeter.

change in range by adjusting the spacing between the high-voltage electrode and grounded electrode of which the moving element usually forms a part. It is interesting to consider the developments in these instruments over a few years as shown in Figs. 11, 12, and 13. In the early design of Abraham and Villard (*41*) (1911), Fig. 11, the curvature of the disk and guard is nearly spherical. The moving system is rather massive with a separate damping chamber within the guard. The Imhof (*44*) (1926) design, Fig. 12, provides a flattened guard ring and fits the light-weight attracted electrode into its own damping chamber. Starke and Schroeder (*43*) (1928) in one model, Fig. 13, employed a relatively larger flat-guarded electrode and a flat-strip suspension for the movable rectangular flat electrode, *P*, providing it with a mirror instead of a mechanical pointer, as well as with a balanced damping chamber arrangement. Nearby objects would be increasingly less effective in producing deflection errors at equivalent spacings in the later voltmeters. These voltmeters may be read to closer than 1 percent but unless calibrated in place, especially when used at large spacings at maximum rated voltage, are likely to be affected by nearby objects.

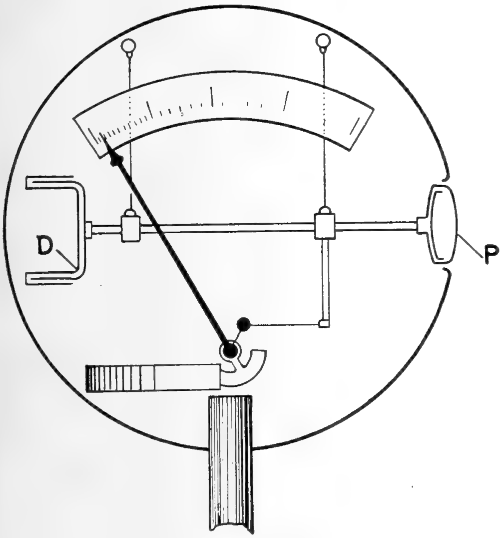

Fig. 11.—Abraham and Villard electrostatic voltmeter.

Ellipsoidal voltmeter.—The ellipsoidal voltmeter of Thornton and Thompson (*53*), illustrated in Fig. 14, is of the nature of an electrometer and satisfactory theoretical equations have been developed for it. It, like the electrometer, depends on a relatively undistorted axial field if it is to be used as an absolute instrument.

The moving element consists of a metallic ellipsoid of revolution carried on a bifilar silk suspension and is provided at its lower end with a reflecting mirror and damping

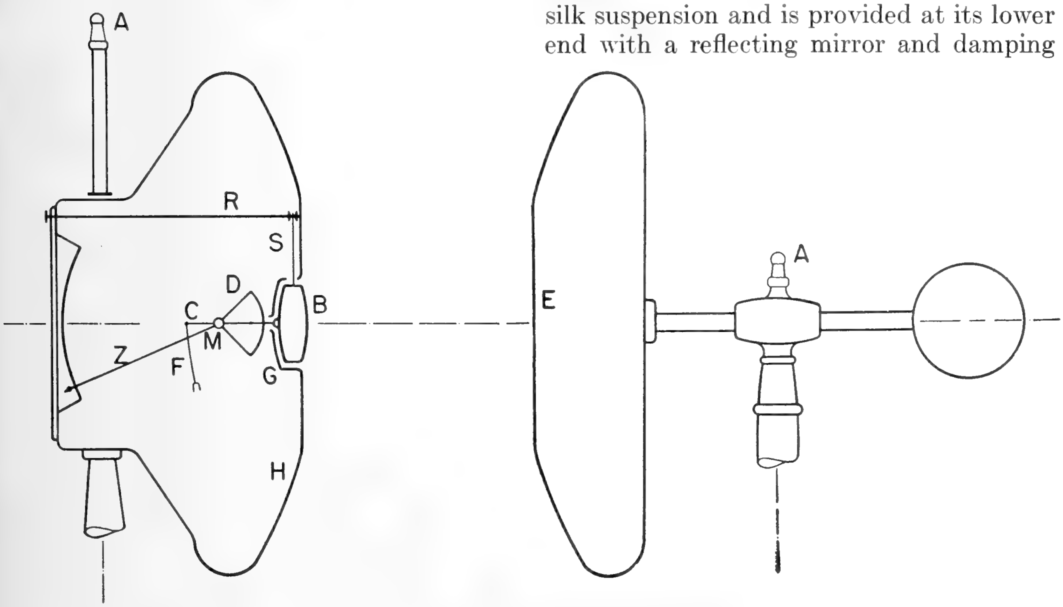

Fig. 12.—Imhof electrostatic voltmeter.

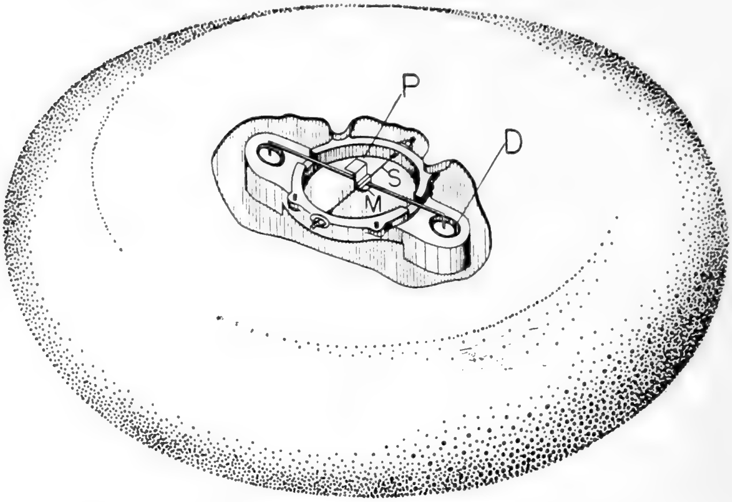

FIG. 13.—Starke and Schroeder electrostatic voltmeter.

vane. The ellipsoid is suspended with its long axis horizontal and is centrally located between two vertical circular plates facing each other and at an adjustable distance apart. Polarization of the ellipsoid by the electric field established between the plates by the source of voltage to be measured, gives rise to a mechanical couple tending to align the ellipsoid, which is initially set at an angle to the horizontal axis perpendicular to both plates. Although the change in the angular deflection of the ellipsoid may be used as a measure of the voltage applied, a more sensitive and rather interesting method of voltage indication has been contrived which involves measuring the increase in frequency of its swings when voltage is applied. Thus:

$$E = k(n^2 - n_o^2)^{1/2} \qquad (1)$$

where E is the electric field strength, k is a constant found from dimensions, n is the number of swings per second with the voltage on, and n_o is the number of swings per second with the voltage off.

Sufficiently large plates are used and at such a separation that the electric gradient E throughout a considerable volume along the axis would be substantially uniform if the ellipsoid were not present. Since the disturbance effected by the ellipsoid is small, the voltage applied to the plates is

$$V = Ed, \qquad (2)$$

where d is the plate separation.

The instrument described was designed for measurements up to 200 kv. As shown schematically in Fig. 14 the plates were 140 cm in diameter and were spaced as much as 100 cm apart (i.e., average gradient of 2 kv per cm). An exploration of the field indicated that it was quite uniform at the midpoint between the plates within a radial distance of 25 cm; however, no study of its longitudinal variation appears to have been made. Great care was taken to insure that the ellipsoids of revolution were accurately shaped so that the theoretical relationships would apply. One ellipsoid of duralumin was 3.9692 cm long and 0.5970 cm in diameter and weighed 2.0496 grams.

The electric gradients at the tips of the ellipsoids are considerably higher than the average gradient between the plates. These gradients must be kept well below corona-forming values if disturbing effects from electric wind are to be avoided. In its practical form where it is to be used as a deflection instrument for laboratory or shop measurements an insulating enclosure is provided for the suspension, ellipsoid, mirror, and damping mechanism to shield them against wind and dust. At the bottom end of the moving-system assembly the damping vane is suspended in a damping chamber attached to a tube whose upper end is cemented to the bottom of a hollow glass sphere in which the ellipsoid is centered. The upper end of the sphere is cemented to a second tube housing the bifilar

suspension and an adjustable suspension control for changing the period of swing. The control mechanism and the torsion head are mounted at the supported upper end of the tube. A spherical shape was used for the hollow glass sphere enclosure for the ellipsoid so as to permit a theoretical evaluation of the effect of the dielectric of the sphere on the electric field E at the ellipsoid. The theoretical correction derived for this spherical glass enclosure agreed well with experimental results when the relative humidity was not high enough to cause electrical surface leakage.

The ellipsoidal voltmeter is said to be accurate to 0.1 percent and to be only slightly affected by humidity. Because of low average gradient, 2 kv eff/cm, it appears to be more bulky than other electrostatic voltmeters and is of interest mainly because it is a unique arrangement permitting absolute measurements.

Sparkless sphere-gap voltmeter.—Large spheres ordinarily used as sphere spark-gap voltmeters in measuring high crest-voltage have been modified to permit their use as electrostatic voltmeters for measuring the effective value of voltage at spacings slightly in excess of sparking distances. This arrangement has been called a sparkless sphere-gap voltmeter (*47*).

Hueter (*46*) employed a vertical arrangement of 1-meter spheres. The upper high-voltage sphere was supported on a spring whose additional extension as a result of the electrostatic force was magnified by a lamp-mirror-scale arrangement. The spring and the mirror optical-lever arrangement were mounted within the sphere shank which was provided with a small window. An external arc-lamp and scale were mounted on an adjacent wall in the laboratory and gave satisfactory readings in daylight. The vertically adjustable lower sphere was grounded and its driving screw mechanism was arranged to indicate the gap length. The weight of the upper one-meter sphere was 60 kg and for a 75 cm gap the electrostatic attraction was approximately 800 grams at 1,000,000 volts. In order to minimize effects of changing gap length, only small displacements (less than 0.5 percent of the gap length) of the spring-suspended sphere were used. An oil-cup damper made the sphere motion nearly aperiodic. An accuracy of 1 percent was claimed.

Sorensen (*47, 48*) employed a horizontal arrangement of 1-meter spheres with rather long slender shanks presumably in order to reduce effects of attraction arising from the shanks. The electrostatic attraction of the grounded sphere could be readily measured as it was supported by suspending its shank by four ropes tied to the shank at the apices of the two thus-formed *V*-suspensions. The upper ends of the ropes were attached to ceiling members. This laterally stable suspension possessed only a small longitudinal stability so that differences in longitudinal electrostatic forces of several hundred grams could be measured to better than one gram. A small wire in line with and attached to the end of the grounded sphere shaft ran over the rim of a bicycle wheel thus insuring low friction. A small weight pan attached to the end of the wire permitted weighing the force of attraction.

These two sphere-electrometer devices represent useful laboratory tools for they can be calibrated and used as voltmeters for measuring effective voltage. They can

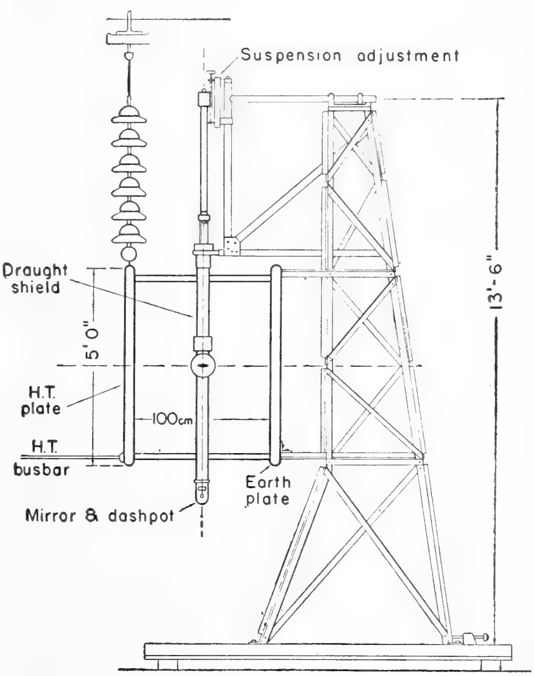

FIG. 14.—Ellipsoidal voltmeter.

also be employed in the usual manner as sphere spark-gaps for the measurement of crest voltage. If one is satisfied with the accuracy of the sphere spark-gap as a high-voltage standard, measurement of the voltage wave form permits calibration of these devices as electrometers for the measurement of effective voltage without recourse to other methods. To a very limited extent they may be considered to be absolute electrometers, particularly if adequate relative clearances to the floor, walls, leads and other conductors and insulators are maintained so that approximate corrections can be made for the presence of these objects. Simple theoretical calculations of the force of attraction can be made by the method of image charges in the case of two insulated or one grounded and one insulated sphere. For a 25-cm spacing of his 1-meter spheres Sorensen considered that no correction was necessary, and at 35 cm the effect of shanks and other nearby objects was said not to exceed 1.5 percent.

One may hope for an accuracy approaching 0.5 percent with the design of Hueter in making relative measurements up to one million volts. This would involve ample clearance for the spheres and first calibrating by an accurate lower voltage method using a separation of the spheres adequate for one million volts and making certain that corona-free electric field conditions exist in the neighborhood.

Disk electrometers.—About 1880 Lord Kelvin made an outstanding contribution by incorporating a guard ring for the disk of the attracted disk electrometer. The guard ring not only validified the use of the simplifying mathematical assumptions in computing the electrostatic force of attraction of the disk but it established the basis for a design whose readings were less effected by nearby objects. When coplanar with the guard ring the force

$$F = \frac{V_s^2 A}{8d^2}, \qquad (3)$$

where V_s the voltage is in electrostatic units, A is the area of the disk, and d the separation from the opposite grounded plate.

For deflections of a guarded disk away from coplanarity, Snow (*54*) has developed a mathematical solution which takes into account the change in force arising from change in position of the disk. This change in force might at first appear only to vary inversely with the separation d (shown by a simple differentiation of equation (3)). However, Snow has evaluated the additional change in force arising from the redistribution of the charges, which in the case of a protruding disk results in an increase in concentration of charge at the edge of the disk at the expense of the charge on the adjacent edge of the guard plate and vice versa in the case of a retracted disk. Troublesome instability in disk electrometers arising from this latter component of force has for a long time been recognized as a weakness in electrometers designed to cover a wide range of voltage measurement by adjusting the spacing d. One may either elect to provide a linear restoring force adequate for all spacings d at a considerable sacrifice in sensitivity at large spacings or provide for some adjustment of the restoring force with change in spacings at nearly constant maximum allowable gradient. The restoring force required to balance the electrostatic attraction in high voltage electrostatic voltmeters and electrometers has been provided by the following devices:

(1) Suspension of the moving electrode on one arm of a gravity balance, i.e., change of restoring force secured by adjustment of c.g. of balance relative to central knife edges (*52, 30*).

(2) Suspension of moving electrode on a coiled spring (*46, 61*).

(3) Pendulous suspension of electrode (*49*).

(4) Suspension of disk electrode assembly on a flat-strip (torsion) suspension (*43, 55*).

(5) Suspension of the disk from a metallic membrane (*50, 51*).

(6) By combining the torque provided by a flat-strip supporting suspension with that produced in a current-balance arrangement of coils which permits adjustment of the restoring force (*55*) by change in current.

The last three types merit special mention because of the novelty of their arrangement. Fig. 13 illustrates the flat-strip suspension arrangement of Starke and Schroeder. The sixth of the above arrangements, used by Nacken (*55*), employs two pairs of "current balance" coils in a con-

nection that permits adjustment of stability as well as of sensitivity. The restoring force arises in part from the vertical strip suspension which carries the disk with its plane vertical as well as the two similarly mounted astatically connected current balance coils. One pair of field coils with current i_f is connected in series aiding one moving coil and provides a torque proportional to i_f for balancing the electrostatic force on the disk; the other pair of coils with current i_m is connected in series opposing so that by reversing i_m and adjusting its value relative to the current in the moving coil the restoring force of the strip suspension toward the null or coplanar position of the disk may be either opposed or aided thus altering the stability of this system by the simple adjustment of the current in this pair of coils. Thus this arrangement permits a desirable adjustment toward higher sensitivity at large spacings of the electrodes where the deflecting force decreases.

The fifth of the above arrangements is exemplified in the devices of Rogowski and Böcker (*50, 51*) (illustrated in Fig. 15) in which an elastic diaphragm D provides the restoring force for the attracted disk. The diaphragm supports an iron-cored coil (above) which is actually part of a current transformer ("Messdose") constructed with two air gaps in its iron core. The fixed coil with its core form the other part of the current transformer which is supplied from a voltage-regulated alternating-current supply. Very small changes in the air gap (moving coil position) suffice to produce full scale deflections of an ammeter connected across the moving coil and this ammeter is calibrated to read the high voltage. As part of this particular moving system, arranged for use in a compressed gas enclosure, a force coil (Druckspüle) K is suspended below in an iron-clad solenoid especially constructed to permit a measurement of force in terms of solenoid current. This arrangement permits, prior to assembly of the unit in the compressed gas chamber, a direct calibration with known weights on the disk for current in the solenoid against deflections of the diaphragm as indicated by the ammeter. This preliminary calibration with known weights against current is made in order to permit subsequent checking of the calibration of the electrometer by means of the current instead of weights after it has been filled with compressed gas.

Brooks absolute electrometer.—The absolute high voltage electrometer of Brooks (*30*) (Figs. 16 and 17) is illustrative of what can be accomplished in the way of precision when the attracted disk is supported on one arm of a gravity-type balance. Brooks's modification of the Kelvin electrostatic attracted disk electrometer with guard ring was designed for use in free air up to 275 kv on alternating voltage and was arranged to allow a step by step experimental evaluation of errors not readily calculable. In addition to a guard ring, it employed guard

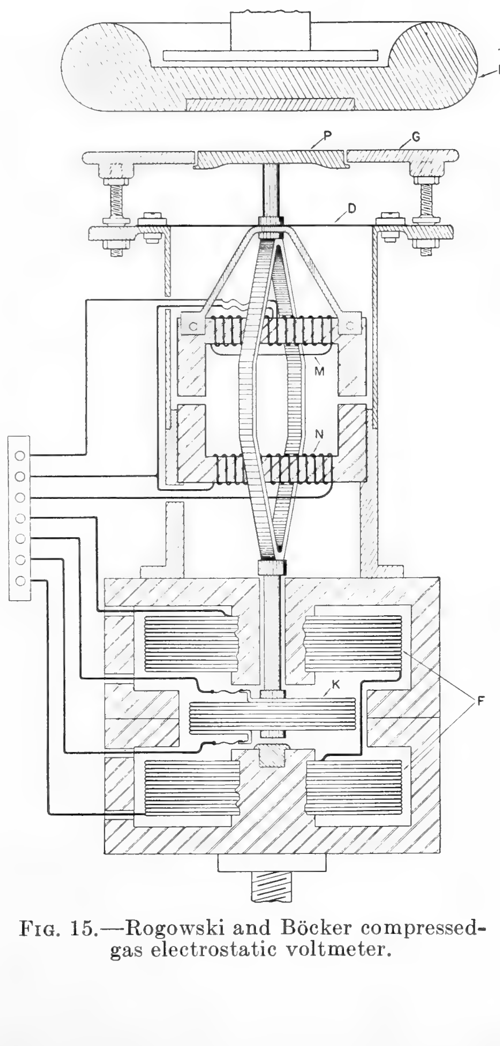

FIG. 15.—Rogowski and Böcker compressed-gas electrostatic voltmeter.

hoops equally spaced between the guarded and grounded electrodes. These guard hoops, spaced 2 cm apart, are connected to tap points on a potential dividing capacitor also across the voltage source. Thus the equally spaced hoops are maintained at equally spaced potentials corresponding to the voltage applied between the high-voltage (upper) and grounded (lower) plates of the electrometer. The hoops not only screen

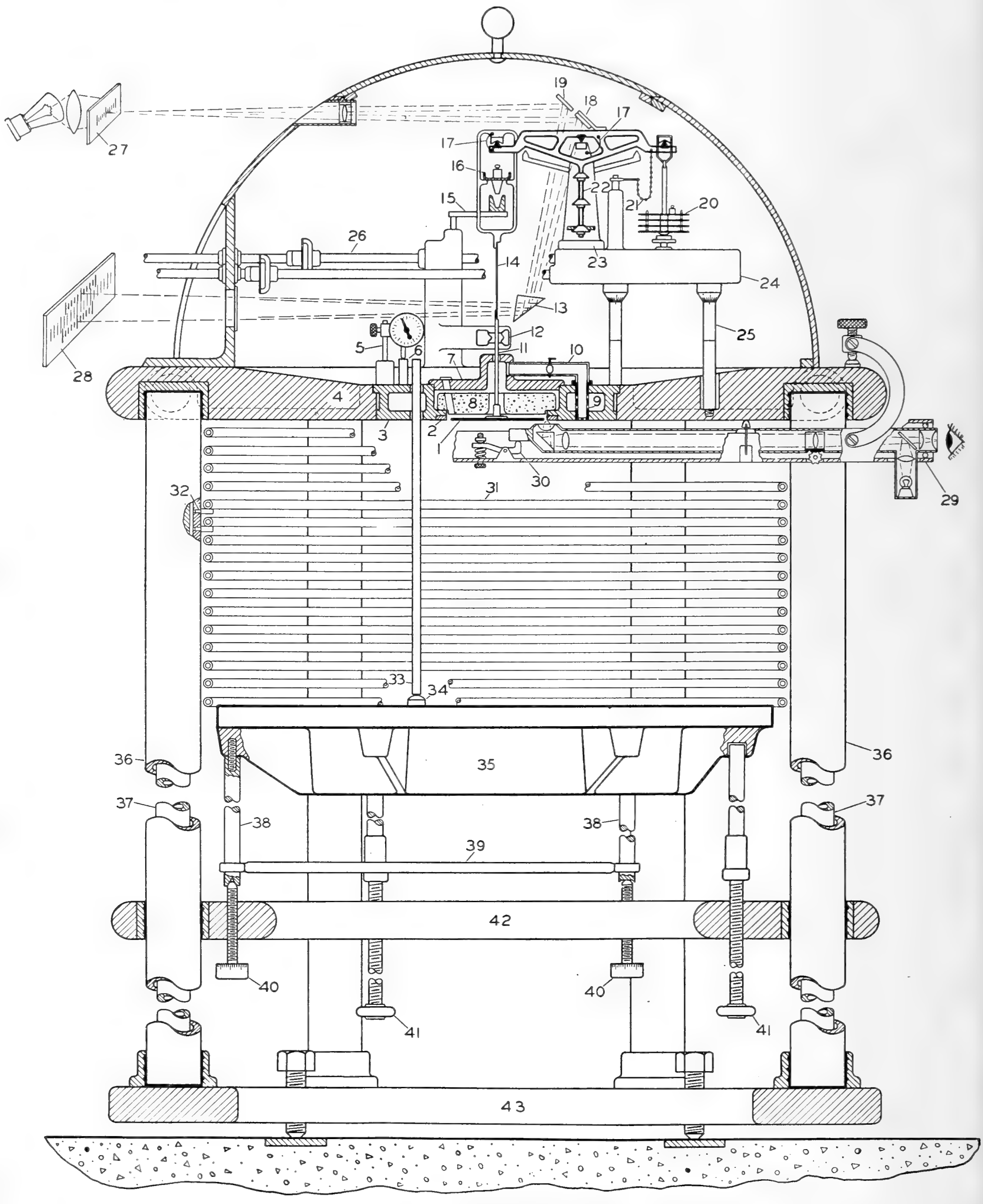

FIG. 16.—Brooks attracted disk electrometer (schematic).

the disk from external fields, but by their potential distribution tend to correct, within their diameter, electric field distortion that would otherwise arise from edge effects at the upper guard ring and lower plate. A mathematical solution of the contribution to force on the disk arising from these hoops has been carried through by Snow (*54*) and Silsbee (*30*) and has been demonstrated to be adequate by suitable experimental tests.[6] For instance by omitting hoops, or electrically shorting various sets of hoops, their potential distribution was changed drastically. For such conditions when the corresponding corrections were applied based on the mathematical solution and experimentally measured potential distribution, very good agreement in the measured values of voltages was obtained.

As a result of the work on the Brooks Absolute Electrometer, which was compared with the transformer voltmeter method of measuring voltage, it was concluded that this instrument is reliable for absolute determinations to about 0.01 percent. This work was limited to 100,000 volts—approximately one-third its rated voltage—because the clearances in the space in which the equipment was housed were inadequate. Results up to full rated value, 275 kv, are not yet available. (With the cessation of the war it is expected to extend the measurements to higher values of voltage in the modern High Voltage Laboratory of the National Bureau of Standards.)

[6] The simple equation (3) may be rearranged $V_s = 2d\sqrt{2F/A}$. This equation may be thought of as being satisfactory for measurements yielding an accuracy of 1 per cent. If an accuracy of 0.01 per cent is desired, correspondingly refined experimental techniques must be employed and additional physical measurements must be made as indicated by the larger number of terms in the complete equation for the voltage in electromagnetic units of the Brooks electrometer,

$$V_M = \frac{4v(c+h_d)\sqrt{2M_F g}}{(r_b+r_d)}\left[1+\frac{A_v-A_o}{2M_F g} + \frac{\gamma}{M_F}(S_v-S_o) - \frac{f(S_v-S_m)}{2q} + \frac{fh_m}{2} - \sum_{k=1}^{k=\infty} C_k G_k - \frac{\epsilon-1}{2} + \phi_1\left(\frac{h_d}{r_d}\right) + \phi_2\left(\frac{s}{r_h}\right)\right].$$

Compressed gas electrometer.—A consideration of the compressed gas electrometers of Tschernyscheff (*56*), Palm (*57*), Rogowski, Böcker (*50, 51*), and others who attained accuracies approaching 0.1 percent leads one to consider whether additional design features might be incorporated in the compressed gas type in order to give an accuracy approaching that of the Brooks electrometer in free air.

Actually the matter of precise weighing of the forces (less than 2.5 grams) on a 16-cm diameter disk, involved in the Brooks electrometer offers no serious problem in free air aside from the necessity of providing a carefully thermostated enclosure to avoid air currents. The possibility of having correspondingly higher forces to measure has its appeal. In the Rogowski and Böcker voltmeter the maximum force of attraction of the disk may reach 250 grams and is measured to 0.2 grams. Thus the forces employed in measurements are one hundred times as large as in the Brooks electrometer, however, the relative accuracy of measurement of this larger force is less in their device.

At the outset one would have to provide a force-measuring device approaching the accuracy and repeatability of a high-grade gravity balance, i.e., something better than that incorporated in the Rogowski and Böcker electrometer. Smaller-scale length measurement would have to be made with about the same relative accuracy and the flat metal surfaces of the plates would require a high quality optical finish. The greatest loss involved in the use of compressed gas rather than free air, as in the Brooks electrometer, lies in the relative difficulty of making and checking mechanical measurements under pressure before and after voltage observations.

The immediate gain from the use of compressed air (*15*) or other gases (*51B*) is to increase sparkover voltages nearly in proportion to pressure. For instance in the design for use to 400 kv alternating, Böcker used carbon dioxide at 15 atmospheres pressure which permits a gradient of 100 kv eff/cm as compared with 2.5 kv eff/cm in the Brooks electrometer as limited by the present potential dividing capacitor con-

nected to the hoops. Gaseous "freon" (*58*) (dichlorodifluoromethane) has between smooth electrodes about 2.3 times the breakdown strength of air at pressures up to six atmospheres where it still remains gaseous. In the case of points or sharp edges the relative breakdown strength of freon is still higher. Freon has the disadvantage of breaking down into highly corrosive products if corona or other discharges actually take place in it, making it less desirable than carbon dioxide on that account. Sulfurhexafluoride (*58C*) appears to offer some advantages over freon because of its greater chemical stability and higher equilibrium pressure at normal temperatures.

The greater size of the "free air" as compared with the "compressed gas" electrometer appears to be its chief drawback, making it too cumbersome at the highest voltages.

DEFLECTION OF FREE-MOVING CHARGED PARTICLES AND THE HIGH VOLTAGE SCALE

The cathode ray oscillograph and electrostatic (and magnetic) analyzers are examples of devices that employ the deflection of free-moving charged particles. Employing for this discussion the relations given by Hanson and Benedict (*59*), if a slowly moving stream of charged particles is accelerated in vacuo along an electrostatic field of total voltage V_a then

$$V_a e = \tfrac{1}{2} m v^2 \tag{4}$$

where m is the mass of the particle, v its velocity, and e the charge on the particle. When a stream of particles with the velocity v is directed between parallel plates perpendicular to the electric field established by the voltage V_d between the plates then for the idealized arrangement of plates at the far edge the deflection

$$d = V_d e l^2 / 2 S m v^2 \tag{5}$$

where l is the length and S is separation of the plates. For nonrelativistic velocities if L is the distance to and D the deflection at the screen or receiver

$$D = Ld/(1/2) = V_d e L l / S m v^2 \tag{6}$$

so that

$$V_a/V_d = Ll/2SD, \tag{7}$$

and if the relativistic velocities are taken into account (*59*)

$$V_a/V_d\left(1-\frac{V_a e}{2(E_o+V_a e)}\right)-Ll/2SD, \tag{8}$$

where the rest energy $E_o = m_o c^2$ and m_o is the rest mass and c the velocity of light.

For relation (8) it may be shown that the relativistic correction is about 1 percent for electrons accelerated by a voltage $V_a =$ 10.5 kv and increases to about 14 percent at 200 kv. The existence of a relativistic correction of such magnitudes on account of high electron velocity may be looked on as somewhat of a nuisance and as a limitation of the cathode-ray oscillograph when used for the direct measurement of high voltages. Applications of the cathode-ray oscillograph therefore seem to have been limited to the measurement of lower voltages. As is well known, the beam-accelerating voltage source for V_a is generally maintained as constant as possible in order to preserve the sharpness of the cathode spot. The voltage to be measured (or a fraction of it from the voltage divider) is applied as the voltage V_d to the deflecting plates. V_d is kept sufficiently low to leave the deflection D materially unaffected by the relativistic mass correction for velocity of the electrons.

At first thought the fundamental simplicity of this method of measuring voltage is decidedly appealing. It applies the accelerating voltage field directly to the elementary charge of the electron unhampered by additional matter. As indicated above and by equation (8) there is a disadvantage because the resulting high electron velocities even for relatively low-voltage accelerating fields become so large that relativistic corrections for moving charges must be introduced. Thus on second thought, the method involving the acceleration of electrons appears far from ideal but an examination of equation (5) indicates the advantage to be gained by using charged particles of greater mass than the electron because of the resulting lower velocity. Although what one might consider a practical

device for everyday use in the measurement of high voltage by deflecting a stream of free-moving positively charged particles has not been developed, the nuclear physicist has used such a device in his work for a number of years. To help him on his way in measuring high voltages he has established the High Voltage Scale. A short digression in explanation of how this was accomplished seems in order prior to a presentation of the contribution of the free-moving charged-particle deflection-method in this work.

The study of atom physical phenomena

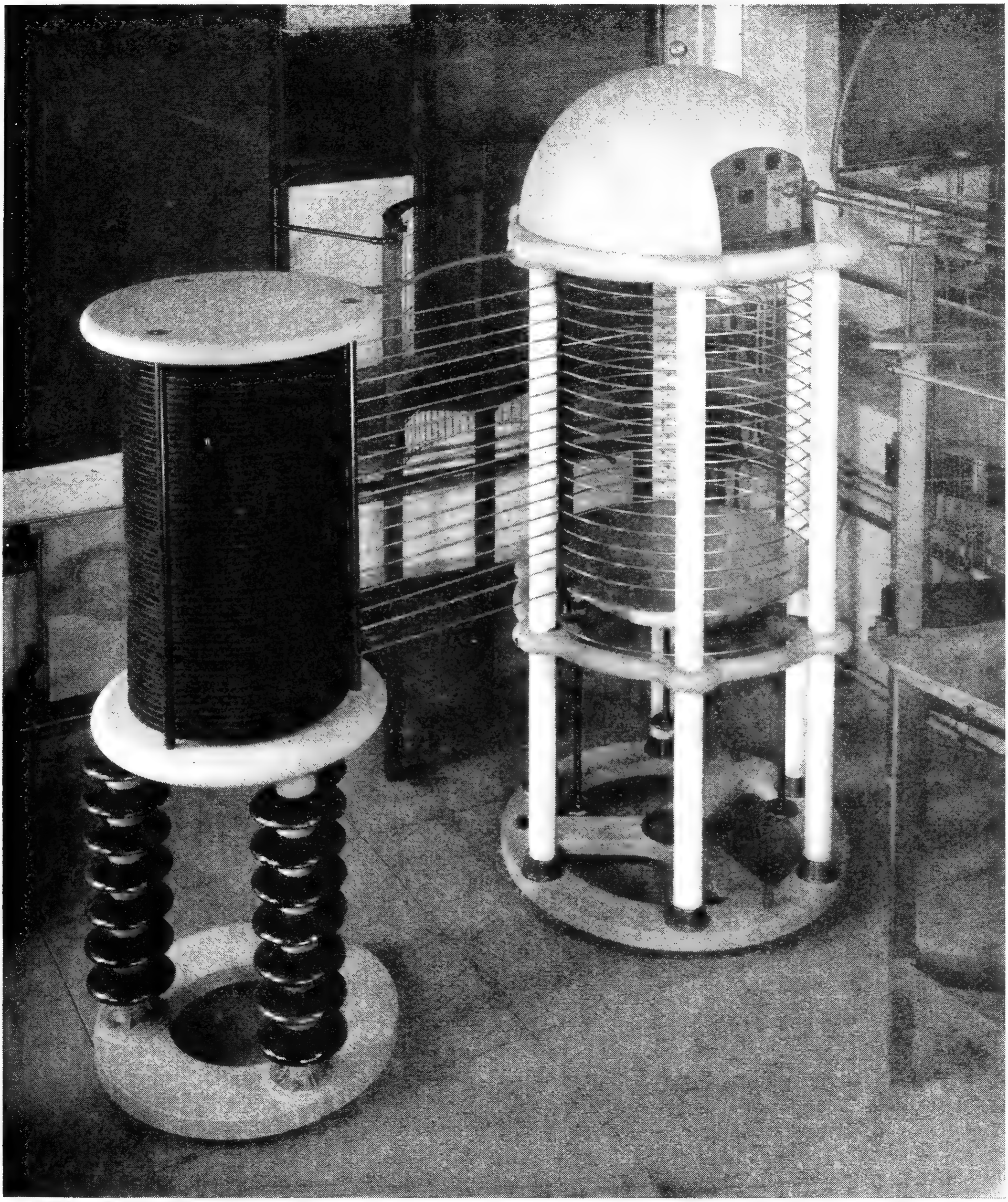

FIG. 17.—Brooks attracted disk electrometer.

led to the physicists' need for a voltage reference standard of the order of 1,000,000 times the voltage of the standard cell.

Historically, one may go back to Planck's equation $h\nu = Ve$ wherein h is Planck's constant, ν is the maximum frequency corresponding to the maximum accelerating voltage V, and e is the value of the elementary charge. Duane and Hunt *(60)* used a steady high-voltage storage battery in order to evaluate h from a careful measurement of the accelerating voltage V and the corresponding maximum frequency limit of the continuous X-ray spectrum produced. Since those measurements were made the value of h has been well established by other methods. Thus this relation affords a method of determining V by a measurement of the maximum frequency of emitted continuous X-radiation. Little use has been made of this method as a high-voltage reference standard largely because of the accuracy required in evaluating the frequency. With the advent of work on nuclear disintegration a pressing need for high voltage reference standards became apparent as the usual extrapolation methods of measuring V, the particle accelerating voltage, were both cumbersome and none too reliable. In early bombardment work it was found that resonance radiation of gamma rays occurred within a rather narrow range of the voltage used in accelerating the protons. The early careful measurements by Tuve, Hafstad, and Heydenburg *(11)* of the voltage at which these radiations occurred provided the basis for their adoption of certain values of voltage corresponding to the resonance gamma radiation for selected elements as fixed points on the High Voltage Scale.

The measurement process for establishing values for the fixed points on the High Voltage Scale consists in:

(1) Providing a source of protons which are accelerated by a carefully measured adjustable voltage V.

(2) Directing this beam of protons on a target of a selected element such as lithium or one of its salts.

(3) Measuring the gamma-ray resonance radiation effects by means of Geiger-Mueller counters or similar devices which permit a quantitative measurement of this radiation as a function of the accelerating voltage.

From plotted curves of gamma radiation against accelerating voltage (proton energy) the rather sharp maximum of gamma ray effect fixes the value of voltage chosen as the resonance voltage. By selecting elements for these reactions in which a single sharp maximum occurs and by carefully determining the corresponding voltages in terms of the standard cell, the voltages at which particular reactions occur were established as reference points on the High Voltage Scale. In a similar manner but using a boron fluoride ionization chamber (paraffin surrounding the target tube and nearby chamber) instead of the Geiger-Mueller counter, neutron counts may be made for similar reactions in which neutrons are ejected from the bombarded target by voltage accelerated protons. In this case points for the scale are determined by gradually reducing the accelerating voltage V and choosing that voltage at which there is an abrupt decrease in ionization chamber current as the limiting voltage for ejection of neutrons is reached.

Early experimental values of voltage corresponding to the resonant radiation in the bombardment of lithium by protons was fixed at 440 kv for $Li\ (p\gamma)$ with a probable error of 2 percent and a relative accuracy of 1 percent by Tuve, Hafstad, and Heydenburg *(11)* of the Carnegie Department of Terrestrial Magnetism. A redetermination of voltage values for some of the fixed points was reported in 1944 by Hanson and Benedict *(59)*, of the University of Wisconsin. Their electrostatic analyzer (a device for determining the value of the electrostatic field at right angles to a beam of charged particles that will deflect the beam a given amount) was carefully constructed so that its deflection constant could be computed from dimensions as a check on values determined experimentally. Their experimental method employed an electron beam in place of the proton beam used later in their evaluation of the fixed points. The use of a low-voltage electron beam (accelerating voltages of 8 to 20 kv) and of small deflecting voltages (150 to 360 volts) permitted precise voltage measurements and higher precision for determining the deflection constant of their

analyzer than the absolute method consisting of a computation of the deflection constant using carefully measured dimensions. Various refinements including the use of a highly stabilized source for the deflecting voltage and automatic regulation of the ion-accelerating voltage reduced fluctuations and contributed to highly precise measurements of the fixed points on the High Voltage Scale. Hanson and Benedict consider the following values expressed in terms of the Million Electron Volt scale to be accurate to 0.3 percent: $Li(p\gamma)$ 0.4465, $F(p\gamma)$ 0.877, $Li(pn)$ 1.883, $Be(pn)$ 2.058. Their apparatus gave relative values agreeing to better than 0.1 percent. Their values are seen to agree within the tolerances given for the values of Tuve, Hafstad, and Heydenburg although they are approximately 1.5 percent higher.

The establishment of the High Voltage Scale based on a phenomenon unaffected by temperature, pressure, and humidity except as their abnormalities plague the collateral work of the investigator, thus represents a distinct step forward in the process of better measurements and standards for high voltages.

SUMMARY AND CONCLUSION

The principal methods in use for measuring high voltages have been outlined through the discussion of a number of devices. Mention was first made of the correlation of different methods of high-voltage measurements through extrapolation techniques in which the standard cell was used as the primary standard of voltage. Absolute high-voltage electrometers were later discussed and the good agreement between their independently determined values when compared with a standard-cell voltage-extrapolation method was noted. Concluding remarks cited the use of both the standard-cell voltage extrapolation-technique and a less precise absolute method in establishing the voltage values for certain fixed points on the High Voltage Scale.

At the moment it appears that high voltages as we know them in the laboratory stop with values of the order of 10,000,000 volts. On the other hand, charged particles come to us from space or may be accelerated in the laboratory by resonance techniques to have electron velocity equivalents approaching one hundred times that value. Presumably the future holds in store some new insulating arrangement for the collector of the high energy particles that man is able to produce—an arrangement that will permit the collector to build up to the unbelievable potentials we think of when we hear of a new machine in the rumor or blueprint stage that will produce 1,000 million electron-volt particles. Just what such voltages will be used for and how they will be measured I wish to leave as part of your field of conjecture.

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CHEMISTRY.—*Standardization of the pH scale.*[1] ROGER G. BATES and EDGAR REYNOLDS SMITH, National Bureau of Standards.

The *p*H is not a definite thermodynamic quantity, and the lack of a universally accepted definition of the *p*H scale has led to an unfortunate state of confusion. The two scales of *p*H in common use at the present time differ by 0.04 unit. Some workers are using one definition for computations and measuring a different quantity. To correct this situation it is of primary importance that a single scale be generally adopted (*1*).

Commercial *p*H meters of the glass-electrode type are now found in nearly every laboratory where chemical analyses and tests are performed. These instruments must be calibrated from time to time with buffer solutions of assigned *p*H. Two difficulties are encountered in any attempt to measure *p*H accurately. First, neither the concentration nor the activity of hydrogen ion in a buffer solution can be exactly and uniquely determined. In the second place, the potentials at the liquid junctions between the various standard and unknown solutions and the bridge solution of the reference electrode can never be perfectly matched or eliminated. Measured *p*H values will still be uncertain for this reason, even when exact standards are available. Nevertheless, the larger differences due to lack of agreement on a fundamental definition and on a method of calculation can be avoided by the co-operation of all who determine *p*H. As a means to this end, the National Bureau of Standards proposes the adoption of a standard scale of *p*H having reference points based upon certain reproducible buffers. In this discussion, the advantages and limitations of the several common *p*H scales will be considered, and the nature of the problems involved in an evaluation of the hydrogen-ion activity of the standard buffer solutions from electromotive-force measurements will be indicated.

S. P. L. Sørensen first proposed the use of the hydrogen-ion exponent (Potenz) to facilitate the designation of the extremely small concentrations of hydrogen ion of physiological significance (*2*). This unit of acidity will be called *pc*H. Its definition is formulated

$$pc\mathrm{H} \equiv -\log c_{\mathrm{H}};\ pc\mathrm{H} \equiv -\log m_{\mathrm{H}}, \qquad (1)$$

where c represents volume concentration (molarity or normality) and m is molality. The hydrogen-ion concentration, it was supposed, could be obtained experimentally by measurement of the electromotive force (emf, E) of a suitable galvanic cell. Sørensen chose the cell,

$$\mathrm{Pt};\ \mathrm{H_2(g)},\ \text{Solution} \left| \begin{array}{c} 3.5\text{-}M \\ \mathrm{KCl} \end{array} \right| \begin{array}{c} 0.1\text{-}M \\ \mathrm{KCl} \end{array},$$

$$\mathrm{Hg_2Cl_2\ (s)};\ \mathrm{Hg}, \qquad (2)$$

for the practical determination of *pc*H. The vertical lines represent liquid junctions. Ion transfer across these boundaries gives rise to an unknown liquid-junction potential, E_j, which was partially eliminated by the extrapolation procedure suggested by Bjerrum (*3*).

With the aid of standard solutions composed of hydrochloric acid with and without sodium or potassium chloride, Sørensen determined E^0, the "standard potential" or "normal potential" of cell (2). The hydrogen-ion concentration of these standard solutions was taken to be the product of the concentration of hydrochloric acid and the classical degree of dissociation derived from measurements of electrolytic conductance. By definition, E^0 is the potential of cell (2) when the hydrogen-ion concentration of the solution is 1 normal. Sørensen's value of E^0 is 0.3380 at 18° C (*2, 4, 5, 6*). At 25° C, the standard potential is 0.3376 (*6*). It was intended that the *p*H at 25° C of "unknown" solutions should be computed by the simple equation,

$$ps\mathrm{H} \equiv \frac{E - 0.3376}{0.0591}, \qquad (3)$$

where E is corrected insofar as possible for the undesired potential at the liquid junction between the solution and 3.5-M potas-

[1] Received September 2, 1947.

sium chloride. This experimental pH value defined by Sørensen's value of E^0 is not, as he intended, pcH. It is designated psH in equation (3). The constant 0.0591 in the denominator is the value of 2.303 RT/F at 25° C, where R, T, and F represent the gas constant, absolute temperature, and faraday, respectively.

In the light of modern concepts, it is clear that the laws of ideal solutions can not justifiably be employed in this way. Nor will the classical degree of dissociation yield, as Sørensen assumed, the hydrogen-ion concentration of mixtures of strong electrolytes. Activity now replaces concentration in the equations for the emf. Indeed, at a temperature of 25° C,

$$-\log \mathbf{a}_H = \frac{E - E^{0\prime} - E_j}{0.0591}, \qquad (4)$$

where $\mathbf{a}$ represents activity. The standard potential, $E^{0\prime}$, is referred to unit activity instead of normality and includes the constant chloride-ion activity in the vicinity of the calomel electrode. The activity, $\mathbf{a}$, is the product of concentration, c or m, and an activity coefficient, f. If E_j could be evaluated, the exact hydrogen-ion activity would be forthcoming. Unfortunately, the liquid-junction potential can not be calculated without a knowledge not only of f_H and other activity coefficients but also of the compositions of the multitude of transition layers of which the boundary is composed. For this reason, the activity of a single ionic species is without physical reality (*7*).

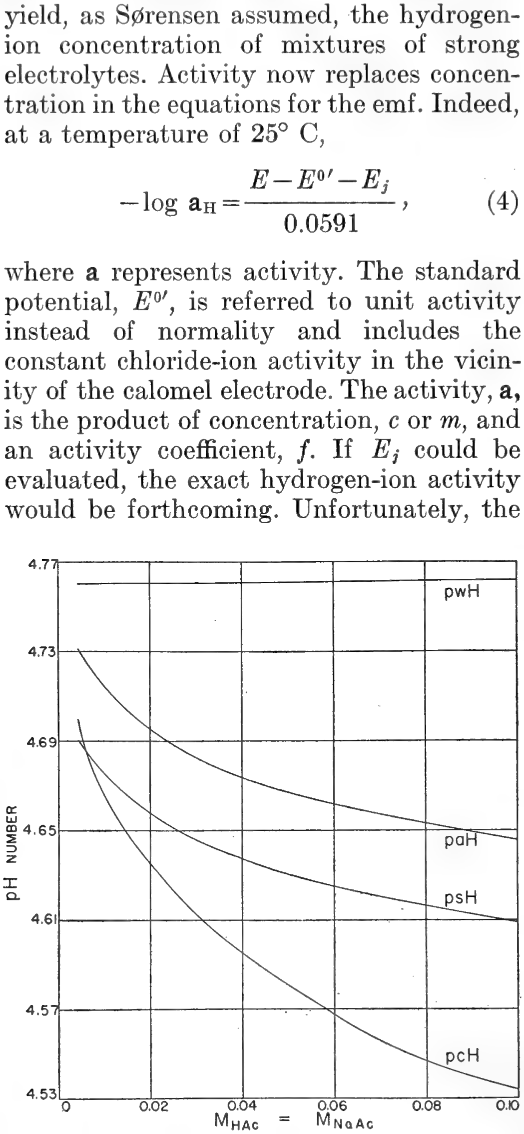

Fig. 1.—pH of acetate buffer solutions at 25° C on four different scales as a function of concentration.

The new concept of the thermodynamics of cell (2) led to the definition of paH by Sørensen and Linderstrøm-Lang (*5*):

$$pa\mathrm{H} \equiv -\log \mathbf{a}_H. \qquad (5)$$

Although paH can not be determined by thermodynamic methods, its character can be simply and unequivocally defined in terms of measurable mean activity coefficients. The paH scale has likewise been defined in terms of the thermodynamic ionization constants of weak acids in dilute buffer solutions (*8, 9, 10, 11*).

The pH values, on these three scales, of buffer solutions composed of equal molarities of acetic acid and sodium acetate are compared in Fig. 1. At infinite dilution, paH and pcH are equal, for the activity coefficient becomes unity by definition in that limit. However, the Sørensen value, psH, remains lower by about 0.04 unit than paH at all concentrations. The pwH, defined as $-\log(\mathbf{a}_H f_{Cl})$, changes but little with dilution. This unit will receive further mention. When it is desired to convert psH to paH, the following relationship will serve with an uncertainty probably less than 0.02 unit:

$$pa\mathrm{H} = ps\mathrm{H} + 0.04. \qquad (6)$$

The Sørensen scale, or psH, is probably the scale most widely used today. The pH values given in the well-known monograph of Clark (*6*) correspond to this scale. Yet psH is neither $-\log \mathbf{a}_H$ nor $-\log c_H$. It usually lies, in fact, between these. When a pH meter is standardized on this scale, all measured values must be corrected to yield a quantity that can be employed in equilibrium computations, if they are to have quantitative significance. The hydrogen-ion concentration possesses the physical reality that the activity lacks. A knowledge of the hydrogen-ion concentration would be useful, but this quantity can not readily be determined by an emf measurement with

the pH meter. For this reason, the activity scale has been chosen as the most practical for general use. We shall now consider the assignment of paH values to the buffer solutions that will serve as fixed reference points on this scale.

Cells without liquid junction are not only somewhat more advantageous from a theoretical standpoint than are cells with liquid junction, but they are also more reproducible and can readily be measured at different temperatures. They are, however, usually impractical for routine measurements. Efforts have been made at the National Bureau of Standards to use emf measurements of cells without liquid junction to establish standards of hydrogen-ion activity with which to calibrate the pH meter. Each emf measurement of the hydrogen-silver chloride cell,

$$\begin{matrix}\text{Pt; } H_2(g, 1 \text{ atm}), \text{ Buffer solution,} \\ Cl^-(m), \text{ AgCl(s); Ag,}\end{matrix} \quad (7)$$

yields a value of $-\log (f_H f_{Cl} m_H)$, if the standard potential, E^0, and the molality, m, of chloride ion in the solution are known, by the following equation:

$$-\log (f_H f_{Cl} m_H) = \frac{(E-E^0)F}{2.303RT} + \log m_{Cl}. \quad (8)$$

If the buffer solution is composed of a weak acid, HA, and its salt, where HA is either a monobasic acid or an acid anion, and pK for the dissociation equilibrium is known, f_r is also obtained unequivocally:

$$\log f_r \equiv \log \frac{f_{HA} f_{Cl}}{f_A}$$

$$= pK - \log \frac{m_{HA}}{m_A} + \log (f_H f_{Cl} m_H). \quad (9)$$

The quantity $-\log (f_H f_{Cl} m_H)$ will be termed pwH. Inasmuch as pwH is thermodynamically exact, its use as a unit of acidity has been suggested (*12, 13*). The pwH of a buffer solution composed of a weak monobasic acid, such as acetic acid, and its salt, however, changes but slightly with relatively large variations in hydrogen-ion concentration, as shown in Fig. 1. For this reason, $-\log (f_H f_{Cl} m_H)$ is often not a useful unit of acidity in spite of the fact that it retains its significance at all ionic strengths. The paH is derived from pwH by adding the logarithm of an ionic activity coefficient:

$$paH = pwH + \log f_{Cl}$$

$$= pK - \log \frac{m_{HA}}{m_A} - \log f_r + \log f_{Cl}. \quad (10)$$

Thermodynamics can offer no help in estimating the activity coefficient of chloride ion in equation (10). For this reason it is usually necessary to resort to theoretical equations or to assumed relationships

TABLE 1—paH OF BUFFER SOLUTIONS WITHOUT CHLORIDE AT 25° C. COMPUTED FROM THE EMF OF CELL (7)

Buffer system*	Molality of each component	Ionic strength	p_1H for— $a_i = 4$	p_1H for— $a_i = 6$	p_2H	p_3H	p_4H	p_5H	paH, cells with liquid junction
Acetic acid +	0.01	0.01	4.714	4.717	4.716	—	—	—	4.700; 4.714
sodium acetate	0.1	0.1	4.648	4.663	4.663	—	—	—	4.640; 4.645
Acid potassium phthalate	0.05	0.053	4.002	4.011	4.010	—	—	4.005	4.000; 4.010
Acid potassium phthalate + dipotassium phthalate	0.01	0.04	5.169	5.177	5.174	5.170	5.164	5.168	
	0.02	0.08	5.098	5.111	5.109	5.100	5.089	5.096	
	0.05	0.2	4.991	5.013	5.019	4.996	4.969	4.987	
	0.1	0.4	4.907	4.940	4.960	4.919	4.867	4.902	
Potassium dihydrogen phosphate + disodium hydrogen phosphate	0.005	0.02	7.017	7.022	7.020	7.018	7.019	7.018	7.026
	0.01	0.04	6.956	6.964	6.961	6.958	6.961	6.959	6.963
	0.025	0.1	6.856	6.871	6.873	6.858	6.865	6.860	6.858
	0.05	0.2	6.767	6.789	6.796	6.767	6.783	6.772	
	0.1	0.4	6.663	6.696	6.716	6.660	6.693	6.671	
Borax	0.01	0.02	9.177	9.182	9.180	—	—	—	9.178
	0.025	0.05	9.172	9.181	9.179	—	—	—	9.167

* When two components are present, their concentrations are equal.

among the ionic activity coefficients in combinations that can be experimentally determined, such as mean activity coefficients or f_r of equation (9). These methods give equivalent results in very dilute solutions. Some of these assumptions will now be considered.

The equations of Debye and Hückel (*14, 15*) represent observed values of the mean activity coefficients of strong electrolytes with considerable success. Thus the Hückel formula,

$$-\log f_i = \frac{Az_i^2\sqrt{\mu}}{1+Ba_i\sqrt{\mu}} - \beta_i\mu, \qquad (11)$$

might be employed to evaluate the activity coefficient of an ion i of valence z_i. In this equation, A and B are constants at a particular temperature for the water medium, whereas a_i and β_i are parameters characteristic of the mixture of ions. At ionic strengths, μ, below 0.1, the linear term can often be compensated by a small change in a_i and the logarithm of the activity coefficient expressed satisfactorily by the first term on the right alone. The magnitude of a_i is of the same order as the ionic diameter in angstroms. Although the numerical value of this parameter lies between 3.5 and 6.5 for many strong electrolytes, there is no known basis for selecting the correct value of a_i for a single ionic species.

Inasmuch as cell (7) is reversible to hydrogen and chloride ions, it would not be unreasonable to assume that the activity coefficient of chloride ion is about equal to the mean activity coefficient of hydrochloric acid in the buffer solution or in a mixture of strong electrolytes of the same ionic strength and composition with respect to cations. Unfortunately, these mean activity coefficients are often unknown. The mean activity coefficient of hydrochloric acid in its pure aqueous solution is well established, however, over a wide range of concentrations (*16, 17, 18*). A practical scale of paH can be defined by assuming the equality of f_{Cl} in the buffer mixture and f_{HCl} in a solution of hydrochloric acid of the same ionic strength.

Another possible approach is the separation of the measured f_r into f_{Cl} and f_{HA}/f_A. Practical considerations limit this computation to buffer systems in which HA is an anion, that is, to systems where A bears a charge different from Cl. The partition of f_r might reasonably be based upon valence relationships valid in very dilute solutions, namely,

$$f_{Cl} = f_{A^-} = f_{A^{--}}{}^{1/4} = f_{A^{---}}{}^{1/9}, \qquad (12)$$

where A^-, A^{--}, and A^{---} represent anions with 1, 2, and 3 negative charges.

Two other separation formulas are most readily described in terms of the parameters of equation (11). When the acid, HA, is a singly charged anion, it has been found that f_r^0, the limit of f_r in chloride-free solutions, can be expressed by

$$\log f_r^0 = \frac{2A\sqrt{\mu}}{1+Ba^0\sqrt{\mu}} + \beta^0\mu. \qquad (13)$$

One method of obtaining f_{Cl} assumes that a^0 and β^0 can be identified with a_i and β_i for the computation of f_{Cl} by equation (11). The other method identifies a^0 with a_i of equation (11) and drops the linear or "salt-effect" term in computing f_{Cl} in a buffer solution that contains no chloride.

These five assumptions lead to five different paH scales (*19*). When $-\log f_{Cl}$ is computed by the first term on the right of equation (11) with a value of a_i not derived from experimental data, the scale will be called p_1H. The p_2H is that unit obtained by setting f_{Cl} equal to f_{HCl} in a solution of the same ionic strength as the buffer solution. Partition of f_r according to the relationships assumed in equation (12) yields p_3H. Identification of a^0 and β^0 with a_i and β_i leads to the unit designated p_4H, whereas omission of the salt-effect term gives p_5H. The paH of buffer solutions without added chloride is thus expressed in terms of experimentally defined quantities by the following equations:

$$p_1\mathrm{H} \equiv (pw\mathrm{H})^0 - A\sqrt{\mu}/(1+Ba_i\sqrt{\mu}). \qquad (14)$$

$$p_2\mathrm{H} \equiv (pw\mathrm{H})^0 + \log f_{HCl}. \qquad (15)$$

$$p_3\mathrm{H} \equiv (pw\mathrm{H})^0 - 1/2 \log f_r^0. \qquad (16)$$

$$p_4\mathrm{H} \equiv (pw\mathrm{H})^0 - 1/2 \log f_r^0 + 3/2\ \beta^0\mu. \qquad (17)$$

$$p_5\mathrm{H} \equiv (pw\mathrm{H})^0 - 1/2 \log f_r^0 + 1/2\ \beta^0\mu. \qquad (18)$$

The relationship among these last three

paH scales is evidently given by

$$p_4\text{H} = p_5\text{H} + \beta^0\mu = p_3\text{H} + 3/2\ \beta^0\mu. \quad (19)$$

In each of these equations the superscript zero indicates that the effect of chloride has been removed by extrapolation to a pure buffer solution without chloride.

The paH at 25° C of several buffer solutions on these five scales is listed in Table 1 and compared, where possible, with the paH derived from measurements of cells with liquid junction reported by Hitchcock and Taylor (*9*) and by MacInnes, Belcher, and Shedlovsky (*11*). Inasmuch as the choice of a_i in equation (14) is partially arbitrary, two p_1H values, calculated with 4 and 6 for a_i, are given. When the ionic strength is 0.01, these differ by only 0.003 unit. The pwH of the acetate, phthalate, phosphate, and borax solutions was derived from published emf data (*19, 20, 21, 22*).

It must be emphasized that thermodynamics offers as much, or as little, support for the choice of one paH scale as another. One cannot state categorically that a particular method of computation is wrong and another right. The assumptions can only be compared with respect to their reasonableness. Chloride ion evidently plays a unique role in these pH equations. None of these formulas can qualify as adequate unless it furnishes the same paH for a given buffer solution in the absence of sodium bromide or sodium iodide, for example, as it gives in the limit of zero concentration of sodium chloride. Electromotive-force measurements of hydrogen-silver halide cells containing phosphate buffer solutions with added sodium chloride, sodium bromide, and sodium iodide (*23*) offer an interesting, though not exhaustive, test of the adequacy of these five methods of computation (*19*). Both pwH and log f_r were obtained for varying ratios of halide to phosphate. The limiting values in the phosphate buffer solutions without halide were found by extrapolation. By fitting f_r^0 to equation (13), a^0 and β^0 were determined as well.

The paH of equimolal phosphate buffer solutions on the p_2H, p_3H, p_4H, and p_5H scales was computed by equations (15), (16), (17), and (18). The values on the last four scales are shown in Fig. 2 as a function of ionic strength. The lines representing these scales are labeled 2, 3, 4, and 5. The results derived from bromide cells are marked with a single prime and those from iodide cells with a double prime. Lines unmarked save for the identifying figure represent data from the chloride cells. The dots (curve 5) are the values of the NBS scale. The upper and lower dashed lines locate the p_1H curve when a_i is arbitrarily assigned the extreme values of 8 and 3 for the computation. The molality of each phosphate salt is one quarter of the ionic strength.

The three sets of p_2H values computed by equations of the form of equation (15) from $-\log\,(f_\text{H}f_\text{X}m_\text{H})$, where X represents halide, and the activity coefficient of the corresponding halogen acids agree well among themselves but are from 0.01 to 0.03 unit higher than curve 5 at ionic strengths between 0.1 and 0.2. It is noteworthy, however, that all methods of calculation give essentially the same paH at low ionic strengths. The course of the true $-\log \mathbf{a}_\text{H}$ curve can never be ascertained. Nevertheless, at ionic strengths of

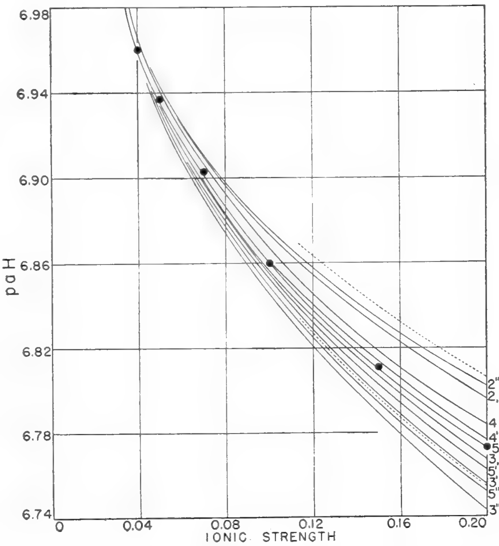

FIG. 2.—p_2H, p_3H, p_4H, and p_5H of phosphate buffer solutions as a function of ionic strength. Curves representing the four scales are labeled 2, 3, 4, and 5. The values were derived from the emf of cells with silver-silver chloride electrodes (unprimed), silver-silver bromide electrodes (single prime), and silver-silver iodide electrodes (double prime). The dashed lines indicate the course of the curve of p_1H for a_i values of 8 (upper line) and 3 (lower line). The dots (curve 5) are the NBS values.

0.01 or below, where all of these reasonable assumptions give practically identical results, the *pa*H can be said to possess some measure of thermodynamic significance.

It is evident that the *pa*H is markedly affected at high or even moderate ionic strengths by the assumption used in its evaluation. For this reason, primary standards of hydrogen-ion activity should be solutions of low salt concentration. Although the true activity is unknown at the higher ionic strengths, the NBS *p*H standards are consistent with one another over the *p*H range 4 to 9.2 at all concentrations to which the *p*H has been assigned. The NBS scale is a true scale of activity at low concentrations. At the higher ionic strengths it is best regarded as a self-consistent scale which, though based upon activity, perforce embraces an assumption not subject to experimental proof. This scale of *p*H appears to be the most convenient and useful to adopt as standard.

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ANTHROPOLOGY.—*The true form of the cranial deformity originally described under the name "tête trilobée."*[1]

T. D. Stewart, U. S. National Museum.

Among the earliest accounts of deformed skulls from America is one by Louis-André Gosse, a Swiss physician-anthropologist, published in 1855. Included in this essay, which is concerned primarily with the classification of deformity types, is the first description of a skull from Isla de los Sacrificios, a tiny island 5.5 km southeast of the port of Veracruz, Mexico. Gosse's description of this skull is of historical importance because the artificial distortion which it exhibited which he characterized as "tête trilobée" has influenced all subsequent generalizations regarding the distribution of deformity types in Middle America. Thus in Dingwall's book on cranial deformity (1931, p. 154) it is stated that—

> The skulls from Isla de los Sacrificios, near Veracruz, where the Spaniards first saw the gory remains of human sacrifice are unusually distorted, and Salas [1921, quoting Gosse] describes them as trilobed on account of the depressions doubtless left by the constricting bandages. This again suggests that at least two important forms

[1] Published by permission of the Secretary of the Smithsonian Institution. Received September 9, 1947.

of cranial deformation were known in Central America from early times, that produced by boards and that produced by bandages.

Also, Imbelloni (1934, p. 65), in plotting out the regions of deformity throughout the hemisphere, says that—

[The Quiché-Huasteca] region presents deformities of the type [*tabular erecto*], with the peculiarity of transverse grooves that, according to Gosse, facilitated the carrying of burdens (they are what Gosse calls *trilobed*). It comprises the coast of Mexico corresponding to the province of Veracruz (with the nearby Isla de los Sacrificios) and Guatemala. (Free translation.)

Recently (1943) a careful archeological investigation was made on Isla de los Sacrificios by the Mexican archeologist Wilfrido du Solier in the course of which several skulls were encountered. Through the kindness of du Solier I was able to examine these skulls during my visit to Mexico City in September 1946. So different from the classical description of Gosse is the type of deformity in these new specimens that I have reviewed the whole subject with the interesting results that follow.

HISTORICAL

According to Gosse, his description of the Sacrificios type of deformity was based upon the cast of one of several male skulls brought to France and deposited in the "Anthropological Museum of Paris" by a French naval officer named "Reymond." The cast was made by a Paris physician, Guy the Elder, and was seen by Gosse in the museum in Geneva. The peculiar trilobed shape exhibited by the cast is clearly shown in Gosse's drawings (Fig. 1).

In 1861, at a meeting of the Anthropological Society of Paris, Gosse again referred to this type of deformity; this time in connection with his paper on a deformed skull from Ghovel, Mexico. Here he uses the term "trilobée" synonymously with "occipito-sincipito-frontale." In explanation he says (1861, pp. 576–577):

The impressions left on the skull seem to indicate that the trilobed form was obtained by means of a thick compress, narrow and long, extending from the neck to the sinciput, that produced a deep depression along the median line of the occipital squama and along the posterior half of the sagittal suture, thus dividing the back of the head into two lobes. Moreover, one or two small compresses were applied on the frontal and the whole was held in place by the aid of two bands, one transverse, passing over the sinciput, and the other circular, passing around the base of the skull. (Free translation.)

Further information on this type of deformity was supplied by Hamy (1884–1891).[2] According to this author, the cast seen by Gosse had been considerably altered ("fortement remanié") and consequently the description based thereon should be modified in many important points (footnote 2, p. 91; footnote 1, p. 93). Furthermore, Hamy states that the skull from which this cast was made may have come from the Dumanoir collection (footnote 2, p. 91). This was plausible because Captain Dumanoir, who commanded the French corvette *Ceres*, explored Isla de los Sacrificios in 1841 and discovered sepulchers there containing human remains (Mayer, 1844, p. 96). However, all this is difficult to reconcile with Hamy's specific statement (p. 91) that the Dumanoir collection had not been described before 1884.

Besides the Dumanoir collection, Hamy mentions (p. 91) a collection made by a Dr. Fuzier, who excavated at Sacrificios during the French occupation (1838) and who gave to the museum "a certain number" of more or less damaged skulls. Three of these skulls are shown in line drawings of the norma verticalis in Hamy's plates 10 and 11. No other skulls from Sacrificios are specifically mentioned in the text or tables of measurements. A total of 6 specimens, 5 male and 1 female, without reference to collector, is indicated in the table on Hamy's p. 92.

In the plate illustrating the two skulls from the Fuzier collection, which plate I am designating no. 10, are featured two other skulls. These are stated in the legend to be from Sabine Lake and the Reynaud collection. Referring to the relevant text (p. 98), we find that—

[2] This publication appeared in three parts between the dates given. Most bibliographies list it as incomplete, perhaps because plate no. 18 is missing. It does not appear that this plate ever was printed. Moreover, two plates are given the number 10, whereas none bears the number 12. I have assumed from the wording of the text that the plate illustrating the skulls from Sacrificios and Sabine should be no. 10.

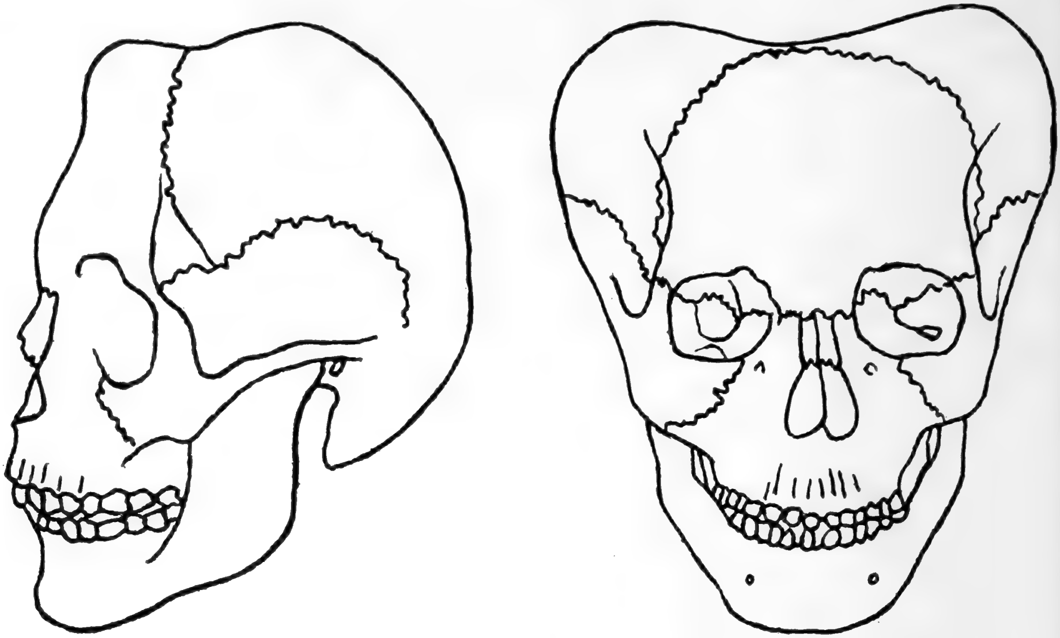

FIG. 1.—Two views of the cast of a deformed skull from Isla de los Sacrificios, Mexico, as illustrated by Gosse in 1855 (pl. 1, figs. 4[a] and 4[b]).

The skulls offered to the Museum of Natural History of Paris by Admiral Reynaud under the name of *skulls from Sabine Gulf of Mexico* do not differ sensibly from those of the second type from the island of Sacrificios.[3]

Footnotes 3 and 4 on the same page offer the additional information that these skulls—

. . . for a long time have been confused under the name of *Sacrificios*, but their primitive label is such that we came to transcribe it. Sabine is the name of a gulf and of a river which forms the boundary between Texas and Louisiana.

Our first type of Sacrificios was not encountered among these skulls. (Free translation.)

Line drawings of one of the skulls said to have come from Sabine are shown in Fig. 2.

Readers will recall that Gosse attributed the original of his cast to the collection of a naval officer named "Reymond." This name is remarkably similar to that of the admiral, Reynaud, who, Hamy says, made the Sabine collection, which was believed for a long time to have come from Sacrificios. Could it be, therefore, that one of these names is an erroneous spelling and that the same collector is referred to? If so, did Gosse really describe a skull from Sabine instead of from Sacrificios? Or is Hamy in error in changing the locality of the collection from Sacrificios to Sabine? These are important questions, because if it can be proved that this deformity type occurs as far north on the coast of the Gulf of Mexico as the boundary between Texas and Louisiana, another cultural link between Mexico and the southeastern United States will have been established.

Further search in the literature has brought to light two references that clarify this subject somewhat:[4] (1) In Larousse's *Grand dictionnaire universel du XIX[e] siècle* (1875, vol. 3, p. 1136) there is a biography of a distingusihed French naval officer by the name of Aimé-Félix-Saint-Elme Reynaud who began his maritime career in 1827. In 1850 he became Captain of a frigate and in 1864 a Vice-Admiral. This biographical dic-

[3] Hamy's second type of deformity corresponds to Gosse's "tête trilobée." Hamy's first type is based upon a single specimen and differs merely in having a greater compression of the frontal bone.

[4] I am indebted to Mrs. Elizabeth H. Gazin, U. S. National Museum librarian, for locating these references.

tionary fails to list a "Reymond." (2) A footnote to a paper by Serres (1855, footnote 1, p. 46) reads in part as follows:

> The ideal beauty that the Aztecs sought to produce was favored by the normal elongation of the bones of the skull and face of this tribe. By compression they only exaggerated their normal type. *This is true also of the skulls which for the first time have been given to the museum by Reynaud, distinguished officer of the French navy and so far found only in the island of the sacrifices, in the Gulf of Mexico.* All of the bones of the skull and face are large, the inverse of the preceding. The compression thus was exerted in inverse sense; it was for the purpose of enlarging the skull and giving it the trilobed form that they represent . . . . (Free translation; italics mine.)

Since Serres' paper was published in the same year—1855—as that by Gosse, and both he and Gosse refer to a collection of skulls from Sacrificios given earlier to a Paris museum by a French naval officer, it seems reasonable to believe that they are speaking of the same event.[5] Furthermore, since Serres gives this officer's name as "Reynaud" and there was a distinguished French naval officer by that name living at that time, whereas Gosse gives this officer's name as "Reymond," for which there is no corresponding biographical record, it seems likely that Gosse misspelled the name. Such misspelling is understandable because in longhand a's may look like o's, u's like n's, and m's like n's.

[5] Gosse (1855, Paris ed., p. 40) states that Prof. Serres gave him permission to examine the specimens in the anthropological museum.

What is still not explained is the later confusion as to the provenience of this collection. It seems to have been well established in 1855 that Reynaud obtained it from Sacrificios. And yet in 1891 Hamy reports the old label as reading "crânes de Sabine, gulfe du Mexique." In view of the improbability that a French naval officer would have an opportunity just prior to 1855 to carry out archeological excavations in the region of Sabine Lake (Texas-Louisiana) and in view of the subsequent failure to recover other skulls thus deformed from either Texas or Louisiana, I believe that Hamy was wrong in attributing the Reynaud collection to the Sabine. Therefore, I regard these skulls not only as exhibiting a type of deformity characteristic of Sacrificios, as Hamy admits, but as actually coming from that place.

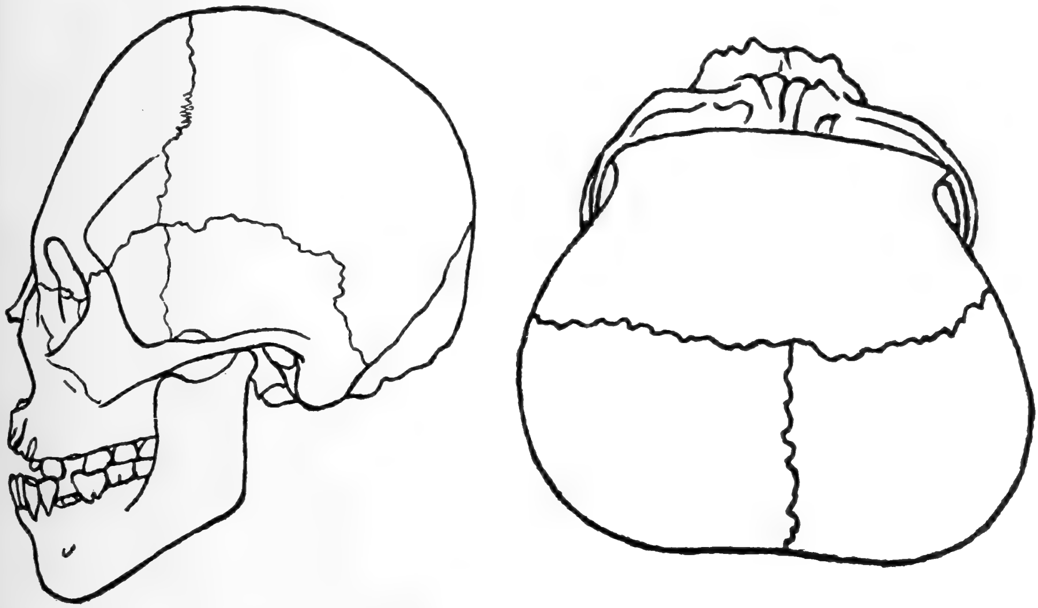

FIG. 2.—Two views of deformed skull no. 5 from the Reynaud collection believed by Hamy to have come from Sabine Lake on the Texas-Louisiana boundary. Redrawn and reoriented from Hamy's illustrations of 1884–91 (pl. 10, figs. 1 and 5).

DEFINITION OF TYPE

Taking into account this decision, let us now summarize what is known about the skulls from Sacrificios. All these, except for the new finds of du Solier, seem to be in Paris and to total at least 15. The early collectors, who visited the island around the years 1838–1841, were Dumanoir, Fuzier, and Reynaud. The only firsthand descriptions of the deformity are by Gosse (1855) and Hamy (1884–1891). These descriptions seem to be based upon extreme cases, for both Gosse and Hamy admit that the artificial characteristics are less pronounced in the majority of cases than they have described them. Thus there is good reason to believe that the skull shown in Fig. 2, which was illustrated originally only because it was believed to come from Sabine rather than from Sacrificios, is more typically deformed. So far as I can discover from the descriptions, only one skull has the curious projection of the upper part of the frontal bone illustrated by Gosse (Fig. 1). This one specimen seems to have furnished the excuse for the name "tête tri-

FIG. 3.—Two views of a deformed skull collected by du Solier in 1943 on Isla de los Sacrificios, Mexico. (Photographs supplied by the Museo Nacional of Mexico.)

lobée" under which this deformity is generally known.

If we ignore this extreme case, the deformity can be recognized by the following characteristics: (1) When the skull is held in the Frankfort position the vertex or highest point is at or near bregma; (2) looked at from above, the skull is very broad, sometimes broader than long; (3) the posterior parietals are pressed downward and forward, sometimes with accompanying compression of the frontal and/or occiput (the latter tending to assume a vertical plane); and (4) there may be more or less of a depression along the sagittal suture and behind the coronal suture. A skull deformed in this manner suggests that it has had its growth restricted along the midline of the vault and consequently that expansion took place laterally, Also, when compression is high upon the parietals the skull appears to have a low vault.

The skulls recovered by du Solier are not markedly distorted. Indeed, the lateral view of the skull shown in Fig. 3 looks undeformed. This is due to the fact that the flattening of the posterior parietals in this case is asymmetrical (see vertical view) and the least involved side has been presented to the camera. As a matter of fact, this skull illustrates, if not ideally, the really significant element of the Sacrificios deformity type; namely, the inclined compression plane involving the posterior parietals and the upper part of the occipital. In accordance with current custom I am calling this element of the deformity "lambdoid" flattening, although it might with more accuracy be called "obelionic" (Stewart, 1939). As I have shown elsewhere (Stewart, 1947; in press), lambdoid flattening, with or without frontal and/or occipital compression, made its appearance in late prehistoric times throughout a large part of Mexico. Having seen numerous skulls with lambdoid deformity from other late sites in this region, I have no doubt that this is the true and significant form of the Sacrificios deformity type.

The so-called lobation (double or triple) which is present in extreme cases of the deformity and which Gosse stressed, appears to be a secondary feature. Owing perhaps to the pattern of cranial growth under artificial restraint there is present sometimes a postcoronal depression and a depression along the sagittal suture. The opposite condition, an expansion, usually characterizes the midparietal parts in these cases. Thus the effect is that of lobation. Because some lobation can be found in all classes of deformity and wherever deformity was practiced, I attribute it to altered growth processes rather than to direct pressure from longitudinal and transverse constricting bands.

In view of what is here pointed out, generalizations regarding the distribution of deformity types, such as that of Imbelloni, are misleading where they have to rely upon early descriptions of atypical specimens and where the chronological sequences have not been worked out.

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BOTANY.—*Studies in* Lonchocarpus *and related genera, III:* Humboldtiella *and* Callistylon.[1]

FREDERICK J. HERMANN, U. S. Department of Agriculture.

Next to *Willardia* the two plants most frequently confused with *Lonchocarpus* in America are *Humboldtiella ferruginea* (HBK.) Harms and *Callistylon arboreum* (Grieseb.) Pittier. Belonging as they do to the tribe Galegeae, both of these shrubs or small trees of arid open or sparsely wooded slopes, coasts, and roadside thickets are readily separable when bearing mature fruit from *Lonchocarpus* and other genera of the Dalbergieae by their dehiscent pods. Their alternate (occasionally subopposite) leaflets likewise distinguish them from *Lonchocarpus*. But, like many tropical shrubs, they have a tendency to drop both pods and leaves toward the end of the dry season and to burst into flower with the first rains, generally before the new leaf-buds have begun to expand. This leafless flowering stage is particularly attractive to collectors, and the superficial resemblance between their inflorescences and those of some of the Lonchocarpi accounts for the large number of specimens in herbaria referred at least tentatively to the latter genus. In this leafless condition both plants seem to be most readily separable from *Lonchocarpus* by their persistent, indurated, awl-shaped stipules, by the lack of evident bractlets, and by the conspicuous articulation of the pedicels at both base and apex. The calyx, with its deep tube, its comparatively long teeth, and its subbilabiate form, so pronounced in the bud, might also be considered diagnostic.

The combination of the half-dozen or so characters, for the most part of fundamental taxonomic significance, here listed for setting off these two plants from *Lonchocarpus* is found in both the monotypic genera *Humboldtiella* and *Callistylon*. Such an apparently fortuitous combination of characters occurring simultaneously in supposedly separate genera naturally raises the question of their status, and an examination of their history reveals that in each case this has had a varied career.

First known of the two was *Humboldtiella*, originally described by Kunth in Humboldt and Bonpland's *Nova genera et species plantarum* (**6**: 395. 1823) as *Robinia* (?) *ferruginea*. The basis of Kunth's description was a fragmentary flowering specimen, lacking leaves and fruit, collected by Humboldt or Bonpland in the Quebrada de Tacagua near Caracas, Venezuela, and deposited in the quondam Berlin Herbarium (Field Museum photograph no. 2079). In 1924 Harms (Fedde Repert. Spec. Nov. **19**: 12–14) pointed out its departure from *Robinia*, in its rostrate carina and narrow pod with unmargined lower suture, and from *Coursetia*, which does possess these characteristics, in its broad, short calyx-teeth and its coalesced vexillar stamen. Because of these discrepancies he proposed for it the new genus *Humboldtiella*. Pittier, however, maintained (Journ. Washington Acad. Sci. **18** (8): 209. 1928) that the only character that would exclude it from *Robinia* "is the absence of a conspicuous margin on the upper suture of the pod, which would certainly not be sufficient to establish a new genus"—a conclusion difficult to reconcile with the fact that the plant differs from *Robinia* in possessing monodelphous stamens, a thick, fleshy calyx with short, relatively blunt teeth, and articulate pedicels, in addition to the rostrate keel noted by Harms. At any rate, Pittier seems to have abandoned his original low opinion of the merits of *Humboldtiella* for generic recognition, since in his latest work on the subject (*Leguminosas de Venezuela,*

[1] Received August 7, 1947.

I—Papilionaceas. Boletín Técnico No. 5, Ministerio Agric. y Cría, Caracas, 1944) we find (p. 152): "Como lo había hecho entrever el Dr. Harms, hace algunos años, la planta que acabamos de definir no pertenece realmente al género Robinia. Difiere principalmente en la forma del cáliz y de las semillas, en la ausencia de un ala en la sutura superior de la legumbre y en otros detalles."

The second plant, the Colombian "*Ramoncillo,*" was originally described as *Coursetia arborea* by Grisebach (*Flora of British West Indies,* 183) in 1859. Harms considered it, or at least such material of it as was available to him, to be sufficiently close to *Robinia ferruginea* to be relegated to its synonymy in his transfer of the latter to *Humboldtiella.* This fact seems to have been overlooked by Pittier when he expressed surprise at finding *Coursetia arborea* among the numbers cited by Harms under his *Humboldtiella ferruginea* (*l.c.,* 208–209). His own comment ("Later, when revising the Papilionatae for the Venezuelan Herbarium, I was surprised to find that, among the numbers cited by Dr. Harms as belonging to his *Humboldtiella ferruginea,* one (no. 5780) apparently corresponds to *Gliricidia sepium* HBK., another (no. 9078) is unmistakably *Coursetia arborea* Griseb., and only one (no. 6004) belongs to the real *Robinia ferruginea* HBK . . . ") seems to be a more fitting basis for surprise not only because one would logically expect to find *Coursetia arborea* (*Pittier 9078*) cited under *Humboldtiella ferruginea* when treated as a synonym of that species but also because at least the specimens in the U. S. National Herbarium of the other cited numbers bear out Harms's rather than Pittier's determinations, that is, *Pittier 5780* shows no resemblance to *Gliricidia* but is typical *Robinia ferruginea,* while *Pittier 6004* is *Coursetia arborea,* not *Robinia ferruginea.* Following his criticism of Harms's work, Pittier proposes segregating *Coursetia arborea* as the type of a new genus, *Callistylon.* In the proposal of *Callistylon,* its distinctiveness from *Coursetia* is carefully elaborated; but no reference is made to its relationship with *Humboldtiella* until the necessity of keying out both genera arose in the *Leguminosas de Venezuela.* Here we find (*l.c.,* 139–140, 152) carried still further a confusion in the characters of *Humboldtiella* and *Callistylon,* which was already apparent in the original publication of *Callistylon.* In the proposal of *Callistylon* the lateral calyx teeth are described as more or less acute and the lowermost tooth as acute, whereas a new description of *Robinia ferruginea* accompanying the same paper states that the calyx teeth in that plant are obtuse. Exactly the reverse is true, however, as is apparent from Kunth's original description of *Robinia ferruginea* (Humboldt & Bonpland **6**: 395) as having the calyx "lobis . . . acutis" and from an examination of a photograph of the type specimen. In the generic key to the Venezuelan Papilionatae this inversion is perpetuated as "Dientes del cáliz cortos y todos obtusos . . . " for *Humboldtiella,* and "Dientes del cáliz alargados o desiguales, pero siempre el carinal largo y agudo . . . " in the lead for *Callistylon* and *Coursetia* together. The lead setting off *Callistylon* from *Coursetia* describes the calyx teeth as "muy desiguales, los 2 superiores obtusos y unidos, los laterales más cortos y agudos, el inferior otra vez más largo y agudo," but it is only in the bud stage that the teeth could strictly be called very unequal and the lateral teeth shorter than the upper pair. In flowering and fruiting material of typical *Callistylon arboreum* the calyx teeth are subequal, the lateral and lower ovate and obtuse to semiorbicular rather than deltoid and acute as in typical *Humboldtiella ferruginea.* The original description of *Callistylon* calls for a plant with leaflets "petiolulatis . . . exstipellatis," whereas the petiolules are actually stipellate, and describes the style as glabrous as opposed to "basi glabro apicem versus utrinque villosulo," whereas the villosulous character applies equally well to the styles of both plants. *Callistylon* is originally described as having "bracteolae parvae et inconspicuae," but the generic description in Pittier's later treatment specifies "bracteas y bracteolas nullas." Diligent search of the 38 sheets of *Callistylon* available to the writer has failed to reveal any trace of bractlets, but the bracts, although caducous, are fully as conspicuous

during most of the bud stage as are the equally evanescent bracts of *Humboldtiella ferruginea*. *Callistylon* is keyed out from *Coursetia* in *Leguminosas de Venezuela* by the additional character of having "valvas de la legumbre de dehiscencia plana y no elastica," yet the elastic dehiscence of the pods in the Pittier collections of *Callistylon* numbered *7833*, *10780*, and *11447* (the last cited under the original description) could not be more striking.

There can scarcely be any question that the peculiarities of the calyx alone in *Callistylon* are sufficient to set it off generically from *Coursetia*, just as the calyx morphology in *Humboldtiella* is adequate basis for removing *H. ferruginea* from *Robinia*. But between *Humboldtiella* and *Callistylon* there appears to be no distinguishing character of generic rank. The treatment of the two plants by Harms as specifically indistinguishable, and Pittier's inability to consistently separate the two as evidenced by his citation of his collection *6004* (typical *Callistylon arborea*) under *Robinia ferruginea*, would seem to be significant corroboration of this view. It is therefore proposed that the genus *Callistylon* be abandoned, and that *Coursetia arborea* be transferred as follows:

Humboldtiella arborea (Griseb.) Hermann, comb. nov.

Coursetia arborea Griseb., Fl. Brit. W. Ind. 183. 1859.

Callistylon arboreum (Griseb.) Pittier, Journ. Washington Acad. Sci. **18** (8): 212. 1928.

The submergence of this species in *Humboldtiella ferruginea* by Harms is not difficult to understand when one considers the prevalence of collections which are annoyingly intermediate between the two. Of the 53 collections of *Humboldtiella* in the U. S. National Herbarium, 7 can be conscientiously referred to *H. ferruginea*, 38 may be with varying degrees of confidence assigned to *H. arborea*, but 8 are too nicely balanced between the two to justify outright committal in favor of one or the other. On the other hand, the differences between the typical forms of both plants (well illustrated in plates 80 and 81 in Pittier's *Leguminosas de Venezuela*) are too fundamental to permit of their being interpreted as mere ecological extremes of a single polymorphic species, nor is there a geographic segregation of the two sufficiently marked to warrant their designation as varieties (i.e., "subspecies," as currently employed with increasing frequency). A hypothesis of hybridization between the two species, and that of a contemporaneous, fertile and vigorous type, would seem to be the most plausible explanation of the frequency of these transitional forms and the comparative impurity of many of the forms identifiable as possessing predominantly the characteristics of one of the extremes. Geographically the specimens of *H. arborea* at hand represent localities scattered throughout most of northern South America north of latitude 5°, from the Department of Bolívar, Colombia, eastward to Trinidad and the Kanuku Mountains in British Guiana; *H. ferruginea* is almost restricted to the Venezuelan North-Central States of Yaracuy, Carabobo, Aragua, Distrito Federal and Miranda, with one outlying station in Sucre; and the intermediates are apparently centered in two disjunct areas, in the Venezuelan North-Central States where the ranges of the putative parents overlap and on Trinidad and the extreme eastern tip of the Paria Peninsula in Sucre, Venezuela. The nearest authenticated specimen of *H. ferruginea* is from a locality approximately 80 miles west of this second area of extensive hybridization, although Pittier cites two Trinidad specimens that are not available for verification. Harms cites a Brazilian collection under his *H. ferruginea*, as well as reports for Panama and Guiana, but his concept, of course, included both species.

The following key is an attempt to emphasize the more constant characters by which the two species may be separated. Pronounced departures from these distinctions are indicated in the citations of collections below.

Calyx slightly if at all gibbous, generally tapering toward base, averaging 6 mm in length, densely ferruginous-strigose, *tube $1\frac{1}{2}$ to $2\frac{1}{2}$ times length of lateral teeth;* calyx-teeth typically deltoid, acute, lateral averaging 2 mm long; leaflets generally elliptic-lanceolate to oblong-lanceolate, broadest below middle, acute, sparsely strigose above, pilose-strigose beneath.......... *H. ferruginea*

Calyx typically gibbous on vexillar side, generally rounded at base, averaging 5 mm in length, with thinner and paler pubescence, *tube $3\frac{1}{2}$ to 4 times length of lateral teeth;* calyx-teeth typically ovate to semiorbicular, obtuse, lateral averaging 1 mm long; leaflets generally oval-elliptic to oblong, broadest at middle, obtuse, typically glabrous.................... *H. arborea*

SPECIMENS EXAMINED

(All in U. S. National Herbarium, except Steyermark collections in Chicago Natural History Museum)

HUMBOLDTIELLA FERRUGINEA

VENEZUELA: *Ll. Williams 12331*, La Entrada, Carabobo (typical); *Pittier 7594*, between El Encanton and Los Teques, Aragua (typical); *Pittier 9159*, between La Victoria and Los Teques, Aragua (calyx-lobes mostly obtuse); *Pittier 5780*, La Trinidad de Maracay, Aragua; *F. Tamayo 1305*, near Guayas, Aragua; *Pittier 11956*, Los Moriches, Miranda; *A. Allart 283*, near Las Moriches, Miranda; *A. Allart 283*, near Las Mostazas, Miranda (calyx pale); *Steyermark 62403*, between Cumanacoa and Cocollar, Sucre (calyx-tube nearly 4 times the length of lateral teeth).

HUMBOLDTIELLA ARBOREA

COLOMBIA: *R. D. Metcalf 30017*, between Medillín and Antioquia, Antioquia; *Dugand & Jaramillo 2849*, between Cartegena and Turbaco, Bolívar; *H. M. Curran s. n.*, Apr.–May 1916, Island of Mompos, Bolívar; *Bro. Elias 1192*, Puerto Colombia, Atlantico; *Dugand 1181 & 323*, Barranquilla, Atlantico; *Dugand & Jaramillo 4042*, between Juanmina and Cuatrobocas, Atlantico; *Dugand 3640*, Juanmina, Atlantico; *H. H. Smith 935*, Santa Marta, Magdalena (calyx-lobes acutish).

VENEZUELA: *Pittier 10780*, near Valera, Trujillo; *Pittier 13125*, Escuque, Trujillo; *F. Tamayo 1694*, Valera, Trujillo; *Saer 230*, La Ruesga, Lara; *Saer 247*, Barquisimeto, Lara (indument ferrugineous); *A. Jahn 1197*, Humocaro, Lara; *Pittier 7665*, between Valencia and Puerto Cabello, Carabobo (typical); *Pittier 9078*, between Puerto Cabello and San Filipe, Carabobo (calyx-lobes unusually acute); *Pittier 9413*, same, in fruit (calyx-lobes blunt); *Pittier 7631*, near Valencia, Carabobo; *Pittier 10310*, between Caracas and La Guaira, Dist. Federal; *Killip & Tamayo 37053*, Santa Lucía, Miranda; *Pittier 6004*, Siquire Valley, Miranda (typical); *Pittier 7833*, Guatire, Miranda; *Pittier 11447*, El Sombrero, Guárico; *Archer 3025*, between El Sombrero and La Democracia, Guárico (typical); *Ll. Williams 12566*, El Cristo, Bolívar (calyx acute at base); *Steyermark 61488*, Bergantín, Anzoátegui; *Brown, Gillin & Bond 21*, Paria Peninsula, Sucre; *Broadway 796*, Cristóbal Colón, Sucre; *Broadway 809*, same (typical).

TRINIDAD: *Britton 478*, Teteran Bay; *Britton 485*, same (leaflets broadest below middle); *Britton, Hazen, & Mendelson 523*, Patos Island; *Britton, Freeman, & Watts 2704*, Chacachacare; *A. Fendler* in 1877–1880, without definite locality; *Britton & Broadway 466*, Lady Chancellor Road.

BRITISH GUIANA: *A. C. Smith 3092*, Kanuku Mountains.

HUMBOLDTIELLA ARBOREA × H. FERRUGINEA

VENEZUELA: *Pittier 12601*, San Pedro, Yaracuy (calyx nearest *H. arborea;* leaflets nearest *H. ferruginea*); *Pittier 8196*, between Puerto Cabello and San Esteban, Carabobo (calyx proportions of *H. arborea*, but lateral teeth rounded-deltoid; indument dense, dark); *Ll. Williams 10400*, Carmen, Aragua (calyx gibbous but tapering at base, densely hairy, the tube only twice the length of the acute lateral lobes; leaflets of *H. arborea*); *Broadway 266*, Cristóbal Colón, Sucre (calyx proportions of *H. arborea* but teeth nearly deltoid, varying to broadly obtuse; leaflet shape and size of *H. ferruginea*, but glabrous); *Broadway 813*, same (calyx proportions of *H. ferruginea* and lateral lobes acute, but vesture pale; leaflets blunt, not broadest below middle).

TRINIDAD: *Broadway s. n.*, March 7, 1930 (lateral calyx-teeth deltoid but the tube 4 times their length; indument pale); *Broadway 3619*, without definite locality (calyx proportions intermediate, the tube 3 times the length of the lateral teeth; leaflets blunt, but broadest below middle); *N. L. & E. G. Britton 2201* coastal thicket (calyx teeth deltoid but tube 3½ times as long).

ZOOLOGY.—*Some interesting starfishes and brittle-stars dredged by the* Atlantis *in the mid-Atlantic.*[1] AUSTIN H. CLARK, U. S. National Museum.

The Woods Hole Oceanographic Institution has recently submitted to me for examination, through Dr. Louis W. Hutchins, a small but interesting collection of starfishes and brittle-stars dredged by the *Atlantis* in the mid-Atlantic. The expedition on which these were found, Cruise No. 150 of the *Atlantis*, was sponsored by the National Geographic Society, Columbia University, and the Woods Hole Oceanographic Institution. I am much indebted to the Institution and to Dr. Hutchins for the privilege of studying this collection.

The species represented in the collection are the following:

Hyphalaster parfaiti E. Perrier

Locality.—*Atlantis* station 15; mid-Atlantic west of Gibraltar (lat. 35° 37′ N., long. 30° 51′ W.); 3,200 meters; August 16, 1947. Seven specimens.

Notes.—The details of the seven specimens are as follows:

[1] Contribution from the Woods Hole Oceanographic Institution No. 410. Published with the permission of the Secretary of the Smithsonian Institution. Received November 5, 1947.

Specimen	R	r	Cribriform organ	United marginals
1	34 mm.	14 mm.	7	10
2	34	13	9	10
3	33	14	5	9
4	30	11	7	8
5	27	11	7	8
6	17	8	7	4
7	17	7	5	4

Pythonaster atlantidis n. sp.

Description.—$R = 165$ mm, $r = 28$ mm. The height at the center of the abactinal system is 26 mm. The rays are 31 mm wide at the base, tapering rapidly to 10 mm at 30 mm from the base, from this point tapering gradually to 3 mm at the tip. A shallow interradial sulcus runs from the middle of each interradius to the center of the disk. The animal may be described as broadly stellate, with each point of the star produced into a long and slender arm.

There is no abactinal skeleton, but the skin is filled with minute rounded plates, which are almost contiguous on the disk and arm bases but become scattered on the outer part of the arms. Among these are the much larger and denser circular lenticular plates, which carry the groups of spines.

On the midline of each ray, running from the center of the disk to the end of the swollen portion of the arm bases, is a band 10–15 mm wide consisting of groups of from 2 or 3 to about 10, commonly 5 or 6, very slender and delicate spines 2–3 mm long arising from a common base on a deeply embedded lenticular plate, the whole enclosed in a bag of thick skin by which the spines are entirely concealed. In a patch about 15 mm long on the inner part of the disk these spine-containing sacculi are intermixed with papulae. On the disk this band of sacculi is bordered on each side by a patch of bare skin through which the large eggs, 2 mm in diameter, are visible. These bare patches may bear two or three sacculi including 4–7 spines. The apical region is closed by 5 large radially placed triangular flaps consisting of numerous delicate spines enclosed in a web of thick skin. The madreporite is situated at the inner end of an interradial sulcus at the outer end of the line between two of these valves or flaps. Just beyond the central valves and bordering the interradial sulcus for about half its length are a few cup-shaped structures consisting of about a dozen slender spines radiating upward from a common base and enclosed in thick skin.

The arms beyond the swollen basal portion are in cross section triangular with the apex rounded, about as high as broad, becoming higher than broad toward the arm tips.

The adambulacral plates have a strongly curved crest which is set at an angle of about 60° with the axis of the arm, the distal end of each crest being considerably farther inward than the proximal end of the crest following. These crests carry a row of 8–10 slender spines which are closely placed with their swollen bases contiguous and are united by a web; the innermost spines are about 1 mm long, those following gradually increasing in length to the outermost, which is 3 mm long. The outer part of each adambulacral plate bears a single much stouter spine 4 mm long, these stouter spines supporting a broad fin-like web which runs along the actinolateral border of the arm resembling the actinal web of many Pterasteridae. Beyond the proximal swollen portion of the arms the adambulacral spines become reduced in number, being usually 5.

Running upward from each adambulacral plate to the dorsolateral border is a band about 1.5 mm broad composed of numerous fine spines arising in small groups, sometimes singly, from a row of independent concretions, the whole band being enclosed in a continuous envelope of thick skin. Beyond the swollen proximal portion of the ray the bands of the two sides meet in the middorsal line. Distally these bands become narrower, the concretions bearing only 1–3 spinelets.

The pair of mouth plates is 9 mm broad at the mouth edge, 2 mm broad on the outer border, and 7 mm long. The line of union of the two plates is raised into a rounded crest. The inner border at the mouth edge is everted and curved, and the outer borders are somewhat concave. The everted inner border of each mouth plate bears 4 large spines, beyond which are 5 much smaller spines. There are no spines on the actinal surface. The mouth plates recall those of some of the Pterasteridae, as for instance *Hymenaster perissonotus*.

The mouth is circular, 23 mm in diameter. The very large stomach is empty. The tube feet, in two series, are large and stout and end in a large sucking disk.

On the arms beyond the swollen basal portion the ambulacral plates are long and slender. The sides of the lower half diverge gradually so that the end adjoining the adambulacrals is

about 2 mm broad, the central portion of the plate being only 0.5 mm wide. The upper third of the ambulacrals is abruptly broadened in the form of a broad Y with very thick arms. When viewed from the exterior the distal arm of the Y is entirely concealed by the proximal arm of the Y of the ambulacral following, which imbricates over it. This causes the ambulacrals when viewed from the exterior, to appear abruptly bent proximally, but when viewed from the interior they are seen to be straight with both arms of the Y about equal.

The adambulacrals as viewed from the actinal edge are seen to be narrowly rhombic, about 3 mm long and 0.75 mm wide. The inner side of the lower angle of the rhombic figure is abruptly swollen, appearing as if a rather thick flat pad had been soldered to it. The distal edge of this pad is evenly curved and bears the spines that form the adambulacral comb. The stout adambulacral spine is situated at about the middle, and widest part, of the adambulacral plate at some distance from the comb-bearing pad and entirely out of line with it. The adambulacral plates are strongly imbricated so that the large spine is in line with the spines of the comb of the plate following, to which it appears to belong unless the arm is cleaned, when its true relationship becomes apparent.

Just above each adambulacral and parallel to its long axis, lying practically on its surface, there is a long, slender and delicate plate 4 or 5 times as long as broad, and a little over half as long as the adambulacral; in some cases there are two of these lying closely side by side. These plates appear to be vestigial marginals.

In a line from these vestigial marginals to the midradial line, as viewed from the inner surface of the skin, there is a regular row of elongate sharply carinate plates 2 or 3 times as long as broad closely placed with their long axes parallel. Between these regular columns of elongate plates (from the center of which on the outer side spines arise) there are very numerous and closely packed minute concretions.

Distally the plates in these columns become smaller, fewer, and more widely spaced, and the concretions become more widely scattered.

Locality.—*Atlantis* station 15; mid-Atlantic west of Gibraltar (lat. 35° 37′ N., long. 30° 51′ W.); 3,200 meters; August 16, 1947. One specimen (type, U.S.N.M. No. E. 7175).

Notes.—The genus *Pythonaster*, the sole genus in the family Pythonasteridae, includes only the type species *Pythonaster murrayi* Sladen described from a single specimen dredged by the *Challenger* at station 323 east of Buenos Aires, Argentina, in 1,900 fathoms, on February 28, 1876.

The type specimen of *P. murrayi* is slightly smaller than the type specimen of *P. atlantidis*, and the bases of the rays are much less swollen; but this difference may be due to the occurrence of large masses of eggs in the type of *B. atlantidis*.

According to Sladen's description and figure the actinolateral areas of *P. murrayi* are traversed by regular rows of isolated skin sacks, whereas in *P. atlantidis* these skin sacks are coalesced into continuous lines. The skin sacks on the abactinal surface of *P. murrayi* are much smaller and more widely separated than those of *P. atlantidis* in which they are almost or quite in contact.

In *P. murrayi* the adambulacral combs are composed of about 6 spines the number becoming reduced to 5 distally. In *P. atlantidis* there are 8–10 proximally, 5 distally. In *P. murrayi* the outermost and largest spine on the adambulacrals is counted as one of the comb, being united to the next by a web. In *P. atlantidis* the outermost spine on the adambulacrals is abruptly larger than the others and relatively much larger than in *P. murrayi* and is joined to the outermost spines on each side by a web, all the spines together and the web forming a continuous broad actinolateral web or fin which appears to be absent in *P. murrayi*.

The mouth plates of *P. murrayi* as figured are not of the same shape as those of *P. atlantidis*. They bear 3 or 4 large inner mouth spines and 3 small outer ones instead of 4 large and 5 small as in *P. atlantidis*. Furthermore, there are in *P. murrayi* spines on the actinal surface of the mouth plates which are not present in *P. atlantidis;* however, in the latter these may have been rubbed off during capture.

With only a single specimen of each species it is impossible to form any idea of the limits of variation. It is possible, though not probable, that *P. atlantidis* is a more fully developed example of the species represented by *P. murrayi*. It is also possible, though not probable, that *P. atlantidis* is a female of the species of which the type of *P. murrayi* is the male; but Sladen did not give the sex of his specimen.

Asteroschema inornatum Koehler

Locality.—Atlantis station 6; mid-Atlantic east of Bermuda (lat. 30° 06′ N., long. 42° 08′ W.), 1,554 meters; August 8, 1947. One specimen.

Notes.—As the original description of this species was brief and lacking in detail the following supplementary information derived from the present specimen may be of interest:

The disk is 6 mm in diameter, stellate with truncated angles and regularly incurved interradial borders; the outer ends of the radial shields are raised about 0.75 mm above the arm bases. The arms are about 60 mm long, slender, 1.3 mm broad at the base and tapering gradually to a delicate tip; they are only slightly higher than broad.

The disk is covered rather thickly with minute granules of coarse and spongy structure. The radial shields are rather broad, widest in the middle, the outer border having a broadly obtuse median angle, and those of each pair are almost in contact. They extend inward for about two-thirds distance to center of disk.

The first two tentacle pores have no scales. The next five have a single tentacle scale. Those following have two scales of which the large inner scale is about a segment and a half in length. At the arm tip the outer scale is only slightly longer than the inner, but neither assumes a hooklike shape. The larger inner scale is cylindrical in the basal third or fourth, from that point being less dense and tapering to the tip. The distal three-fourths bears on the outer side numerous long and slender sharp spinelets, longest near the tip, which through the dried skin appear as small conical points. There are similar but smaller spinelets on the inner side. The small outer scale is similarly armed.

There are 5 stout triangular teeth.

On the sides of the jaw plates within the mouth there are about 8 rather large and well separated granules; these are irregularly scattered, the group as a whole running upward and outward, the outermost being a pair, one on each side of the uppermost tooth.

The skin of the arms contains large delicate filmy plates that appear to form an almost continuous pavement.

The color in alcohol is pale dull pinkish, becoming dark purple on the outer half or more of the tentacle scales.

This species was described by Prof. René Koehler (1907) on the basis of two specimens dredged by the *Talisman* in the Gulf of Gascony (the inner part of the Bay of Biscay) (lat. 45° 59′ N., long. 6° 29′ W.) in 1,480 meters, coral bottom, on August 30, 1883. Sanderson Smith (1888) gives this station as No. 156. Koehler gave the color in alcohol as white.

A single specimen was subsequently dredged by the *Princesse-Alice* at station 2248, in lat. 37° 02′ 30″ N., long. 27° 35′ W., in 1,478 meters, on September 6, 1905 (Koehler, 1909). In his report on the *Princesse-Alice* echinoderms Koehler did not amplify his original description, but he gave a colored figure showing the animal as deep pink, lighter on the radial shields and becoming lighter on the arms after the basal 20 mm.

Ophiura inornata (Lyman)

Locality.—Atlantis station 15; mid-Atlantic west of Gibraltar (lat. 35° 37′ N., long. 30° 51′ W.); 3,200 meters; August 16, 1947. Seven specimens.

Notes.—In these specimens the oral shields are in most divided into two elongate plates meeting in the median line as an angle of about 90°. The jaw plates, the adoral shields, and the two sections of the oral shields are similar, and of about the same size, appearing as three similar chevrons.

In a small specimen one of the oral shields is undivided. In other cases it appears as if the third or outer chevron was composed in reality of a pair of supplementary plates intercalated between the oral shield, much reduced in size, and the adoral shields.

Opiomusium armigerum Lyman

Locality.—Atlantis station 15; mid-Atlantic west of Gibraltar (lat. 35° 37′ N., long. 30° 51′ W.); 3,200 meters; August 16, 1947. Two specimens.

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PROCEEDINGS OF THE ACADEMY

414th MEETING OF BOARD OF MANAGERS

The 414th meeting of the Board of Managers, held in the Cosmos Club, January 12, 1948, was called to order at 8:05 P.M. by the President, Dr. Waldo L. Schmitt. Others present were: H. S. Rappleye, N. R. Smith, H. A. Rehder, M. A. McCall, H. B. Collins, Jr., J. S. Wade, A. Wetmore, W. W. Rubey, L. E. Yocum, W. A. Dayton, C. A. Betts, A. O. Foster, C. L. Gazin, and, by invitation, G. P. Walton, J. I. Hoffman, E. A. Chapin, and A. T. McPherson.

The Chairman of the Committee on Monographs, Dr. E. A. Chapin, announced that estimates had been obtained from several printers for the publication of Dr. Herbert Friedmann's monograph *The Parasitic Birds of Africa.* These ranged from about $1,500 to $2,500 for 1,000 paper-bound copies. Buckram binding increased the estimates $450 to $460. From the record of the sale of Dr. Friedmann's earlier monograph of the cowbirds, Dr. Chapin considered that the present volume, published possibly as a supplement to the Journal, would in all probability pay its way and recommended that the Academy accept it. The monograph was referred to the Board of Editors for further review and recommendations.

Ten persons were elected to membership.

The Chairman of the Committee on Science Legislation, Dr. A. T. McPherson, briefly summarized current activity in science legislation, on which he would report more fully at the annual meeting. His talk was concerned principally with the progress of the Foreign Scholarships program and on H. R. 3342. Dr. McPherson proposed that serious consideration be given to the formation of a study group on science legislation. By an informal showing of hands the outgoing Board recommended to the incoming Board that a Science Legislation Committee or Study Group be reappointed for the coming year.

The Acting Chairman of the Committee on Academy Awards for Scientific Achievement in 1947, Dr. Henry B. Collins, Jr., presented the following recommendations for the three subcommittees:

Biological Sciences: None.

Engineering Sciences: Harry Warren Wells, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in recognition of his distinguished upper-air research and organization of a world-wide network of ionospheric stations.

Physical Sciences: Dr. Robert D. Huntoon, of the National Bureau of Standards, in recognition of his distinguished service in the advancement of electronics and its applications to other sciences and to modern ordnance.

The Board accepted the recommendations, but during the discussion it developed that there existed some misunderstanding as to the age limit of award winners. The Board voted that for future purposes the nominee for the award must not have passed his 40th birthday during the year for which the award was made.

The Chairman of the Committee on the Journal and its Improvement, Dr. R. J. Seeger, reported as follows:

The Committee has had several meetings, including those of special subcommittees, over a period of almost a year. During this time it has reviewed the reports of similar previous committees; it has also consulted with various past Editors of the Journal and with the George Banta Publishing Co. After considering many aspects the Committee unanimously makes the following recommendations pertaining to the Journal and its improvement:

(1) That an index of the Journal be prepared and published for the first 40 volumes and for each succeeding 10 volumes.

(2) That the address of the Retiring President of the Academy be published without charge, including the first 50 reprints with covers.

(3) That each author be allowed, without charge, the equivalent of the first 50 four-page reprints without covers.

(4) That each invited Academy speaker whose address is published in the Journal be allowed, without charge, the first 50 reprints without covers.

(5) That the size of the Journal be increased to approximately 500 pages per year and that the Journal be published economically in issues of 32 or 48 pages—say, 6 issues of each size.

(6) That in each issue one page (the Editorial Page) be allotted to the President of the Academy for his own use or designation.

(7) That the list of officers and committees (standing and special) of the Academy be

published on the third cover page (inside back) of each issue of the JOURNAL.

(8) That Editors of the JOURNAL be continuously vigilant in seeking papers of general interest, in securing copies of outstanding Academy addresses (footnote reference to occasion of delivery), and in selecting papers from different fields for any particular issue.

(9) That the Board of Managers authorize the appointment of a committee to study the functions of the Academy and to formulate a program that will integrate these functions, including the JOURNAL.

The Board voted that the recommendations of the JOURNAL Committee be brought up at the next meeting of the Board.

The Secretary, Dr. C. L. GAZIN, announced the death of Maj. Gen. GEORGES PERRIER, honorary member, formerly of Paris, France, on February 16, 1946; HARDEE CHAMBLISS, formerly of Catholic University of America, on June 1, 1947; and ROBERT H. LOMBARD, formerly of the Norton Company, Research Laboratories, Worcester, Mass., on October 11, 1947.

Dr. HARVEY I. CURTIS was transferred to the list of retired members, effective December 31, 1946.

The following letter to the Secretary from Dr. P. W. BRIDGMAN was read to the Board:

It is a great pleasure to learn that I have been transferred from regular membership to honorary membership in the Washington Academy of Sciences. Will you please express my appreciation to the Board of Managers.

The Treasurer, H. S. RAPPLEYE, announced that the auditing committee had met that morning, examined his books and the Academy securities, and gave him a "clean bill of health." He announced also that the transfer of investment certificates to an account book form in the First Federal Savings and Loan Association, as authorized at the 413th meeting, had been made.

The President, Dr. W. L. SCHMITT, stated that expenses of the Meetings Committee had exceeded the amount of the budget for this purpose and that in order to secure outstanding speakers he had paid out $100.30 more than allowed. It was his hope that, at the close of the Academy Year 1947, the unexpended amounts from the budgets of other offices and committees might be transferred to that of the Meetings Committee, up to the amount of $100.30, but without increasing the budget for the year. The Board authorized that Dr. Schmitt be so reimbursed for the expenditures made by him on behalf of the Meetings Committee.

The meeting was adjourned at 9:45 P.M.

C. L. GAZIN, *Secretary*

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Washington Branch, Society of American Bacteriologists......Lore A. Rogers
Washington Post, Society of American Military Engineers. Clement L. Garner
Washington Section, Institute of Radio Engineers.....Herbert Grove Dorsey
Washington Section, American Society of Civil Engineers.....Owen B. French
Elected Members of the Board of Managers:
To January 1949.....................Max A. McCall, Waldo L. Schmitt
To January 1950.....................F. G. Brickwedde, William W. Diehl
To January 1951...............Francis M. Defandorf, William N. Fenton
Board of Managers....................All the above officers plus the Senior Editor
Board of Editors and Associate Editors...............................[See front cover]
Executive Committee.........Frederick D. Rossini (chairman), Walter Ramberg,
..................Waldo L. Schmitt, Howard S. Rappleye, C. Lewis Gazin
Committee on Membership..
Harold E. McComb (chairman), Lewis W. Butz, C. Wythe Cooke, William
.........W. Diehl, Floyd D. Felton, Regina Flannery, George G. Manov
Committee on Meetings.........................Raymond J. Segeer (chairman),
......Frank P. Cullinan, Fred L. Mohler, Francis O. Rice, Frank Thone
Committee on Monographs:
To January 1949...........Lewis V. Judson (chairman), Edward A. Chapin
To January 1950....................Roland W. Brown, Harald A. Rehder
To January 1951....................William N. Fenton, Emmett W. Price
Committee on Awards for Scientific Achievement (Karl F. Herzfeld, general chairman):
For the Biological Sciences...
C. F. W. Muesebeck (chairman), Harry S. Bernton, Chester W. Emmons, Elmer Higgins, Mario Mollari, Gotthold Steiner, L. Edwin Yocum
For the Engineering Sciences...
Harry Diamond (chairman), Lloyd V. Berkner, Robert C. Duncan, Herbert N. Eaton, Arno C. Fieldner, Frank B. Scheetz, W. D. Sutcliffe
For the Physical Sciences...
Karl F. Herzfeld (chairman), Nathan L. Drake, Lloyd D. Felton, Herbert Insley, William J. Rooney, Robert Simha, Michael X. Sullivan
Committee on Grant-in-aid for Research......................................
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...John W. McBurney (chairman), Roger C. Bates, William A. Wildhack

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JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 38 MARCH 15, 1948 No. 3

PHILOLOGY.—*English-language surnames of biological origin.*[1] PEREZ SIMMONS, Fresno, Calif. (Communicated by JOSEPH S. WADE.)

In the normal course of events every person born in the United States possesses immediately two permanent designations, his family name and his national citizenship. To most people these are perhaps equally precious, but the first is of course the more personal. Family names are treasured inheritances, and even those that may seem, to the other fellow, to be trivial, amusing, or absurd are likely to be continued for scores of generations. Surnames are our handholds on the family tree, and most of us refuse to let go.

The surnames of biological origin listed in this report I have found in telephone directories. Included are plant and animal names and terms referring to the parts of plants and animals (Daisy, Moose, Seed, Antler). Associations of plants and of animals (Orchard, Herd, Covey) are left out, as are also descriptive-anatomical names (Barefoot, Smallback) and physical abnormalities. Not too strictly, I have omitted varieties of domesticated plants and animals (Pippin, Beagle), some products made from and most constituents of plants and animals (Cream, Hay, Leather, Pickles, Pitch), and obsolete words (Poe and Coe for peacock and jackdaw). Most compounds such as those of big, bird, berry, corn, crow, gold, long, short, silver, small, wood, and the names of colors are left out (Birdseye, Greenleaf, Redapple). No attempt has been made to trace derivations. One advantage of making my own rules has been freedom to appropriate names of dual or multiple meanings.

Books and other references on the subject point out that in Biblical times, and until after the Norman Conquest in 1066, ordinary people had only one name, such as Joseph. As populations increased, the convenience of having another name was recognized, and surnames began to be adopted. That was some 700 years before Linnaeus established the binomial system for the science of biology.

In Great Britain the cities were ahead of the countryside in making the change. Whether the surnames established there were allotted to families or were chosen by them without official guidance is not on record in the sources that I have examined. It seems likely that both methods were used. From the wide coverage of the names that I shall list farther on, one would surmise that some system was involved, at one time or another.

Surnames have been grouped under four classifications: locality names derived from the home of the bearer (Kent); patronymics, those referring to the father's Christian name (Robertson); names taken from occupations (Weaver); and nicknames (Fox, House, Longfellow, Stone).

On the whole, the family names that I have found in my hunting through telephone directories have a homespun dignity, an earthy quality that reflects what was prominent and important in day-by-day living on the island of Great Britain 25 or more generations ago. In those days men, women, and children lived closer to their farm animals, their vegetable gardens, and to wild nature than most people do now.

As my collection has grown, and with the use of the Oxford Dictionary and other dictionaries, it has become clear to me that there is no need to seek obscure explanations for the greater number of the biologi-

[1] Received August 22, 1947.

cal surnames found. Nearly all of them, quite evidently, were taken directly from the names of living things of interest in everyday life in Britain before the discovery of America. Doubled consonants, final e's added, and some other departures from modern spellings are for the most part straightforward legacies from olden times.

My first adventure into the vast assemblage of American family names was by way of the Fresno, Calif., Telephone Directory. Since this modest book involved scanning only some 200 linear feet of columns—about 25,000 names—the entire list was searched.

There were 15 tree names listed in the Fresno book:

Ash	Elder	Maple
Bay	Elms	Palm
Cherry	Haw	Peach
Coffee	Holly	Pistacchio
Crabtree	Lemon	Thorn

And 22 varieties of plants which attract attention because of their beauty or utility:

Bean	Ivy	Rice
Bluett	Lilly	Rose
Chess	Mellon	Rue
Cotton	Moss	Rush
Daisy	Nutgrass	Sage
Dill	Pease	Stocks
Furze	Radish	
Grass	Reed	

General plant terms found were Bush and Herb, and plant parts were well represented among Fresno surnames, as follows:

Berry	Cobb	Root
Bloom	Cone	Shuck
Branch	Flower	Stump
Budd	Fruit	Trunk
Burr	Hull	Turnipseed

As might be expected, nearly all of the animal names referred to vertebrates. Fishes, so important to the island-dwelling British, were well represented. All refer to European species but all of their names have been transplanted for use in North America.

Bass	Pickerel	Salmon
Bream	Pike	Sturgeon
Darter	Pollack	Trout
Herring	Ray	Whiting
Perch	Roach	

Farther up the scale are the reptiles, represented by one name only: Asp.

Birds, being conspicuous and abundant as to species, were of frequent occurrence. There were 19 of them, and the majority are of rather large size:

Brant	Heron	Ruff
Coote	Kite	Sprigg
Crow	Knott	Swan
Duck	Martin	Swift
Eagle	Parrott	Wren
Finch	Peacock	
Hawk	Quail	

Excluding domesticated forms there were only 11 mammals, if Fisher is considered to be an occupational surname:

Badger	Fitch	Lion
Batt	Fox	Puma
Bear	Hare	Wolf
Fawns	Hart	

Among miscellaneous terms were the following:

Bird	Fish	Maiden
Child		

Anatomical terms were plentiful:

Beard	Hand	Pate
Brain	Head	Scales
Chin	Horn	Shank
Elbow	Joint	Venter
Furr	Lips	Wing
Gill	Lung	

Names of domestic animals, including poultry, number more than 50. There usually are separate designations for mature males and females, newborn young, juveniles of both sexes, and unsexed males. In addition, call-names and pet names have been used for centuries. Surnames based on these terms probably are nearly all pre-Columbian, since the only domesticated animals native to the Western Hemisphere that have been put to general use by the settlers of North America are the turkey and the muscovy duck. The dog was common to both the New World and the Old at the time of the discovery of the New.

In the Fresno Telephone Directory there were four surnames that refer to the names of farm animals:

Barrows	Lamb	Pigg
Bullock		

Following the page-by-page scanning of the Fresno directory it seemed necessary to change the method of hunting for surnames of biological origin. A detailed examination

of the 455 pages from Aabel to Zzylch in the San Francisco book and of the 1,032 pages of Los Angeles names from Aaen to Zylstra seemed too much of a project. Therefore, lists of terms that probably had been adopted as surnames were compiled. The chief sources of these were the indexes of reference books on botany, horticulture, and zoology. All the findings from both cities were combined and are listed here under several classifications.

Forage plants, small grains, fiber plants, etc.:

Bramble	Darnel	Milo
Bracken	Flax	Rye
Clover	Hemp	Timothy
Corn	Millet	Wheat

Vegetables, flavoring plants, etc.:

Carrott	Garlick	Mustard
Chard	Hops	Onions
Citron	Kale	Parsley
Clove	Leek	Pepper
Collard	Lettice	
Cress	Mangel	

Garden ornamentals, perfume plants:

Aster	Fern	Marigold
Balsam	Flagg	Pink
Broom	Heather	Poppy
Cosmos	Lavender	Primrose

Fruit and ornamental trees were:

Aspen	Hawthorne	Pine
Beech	Laurel	Plane
Box	Limes	Privett
Cedar	Linden	Shaddock
Figg	Medlar	

Other botanical terms in the San Francisco and Los Angeles telephone books were Nut, Plant, Posey, Spore, Stem, and Vine.

As was the case in the Fresno directory, the two leading Pacific coast cities revealed an extensive list of fishes:

Bleak	Eeles	Sauger
Carp	Fluke	Skates
Char	Haddock	Sole
Chubb	Ling	Spratt
Codd	Loach	Tench
Conger	Pilchard	Tunney
Dace	Puffer	
Drum	Rudd	

There was a single form of amphibian, Frogge, and one reptile, Turtle. The birds were even more abundant; 27 were found, not including Loon, a Chinese name:

Bunting	Jay	Rook
Bustard	Lark	Sparrow
Buzzard	Nightingale	Starling
Diver	Ostrich	Stilts
Dove	Partridge	Stork
Finch	Petrell	Swallow
Grebe	Rail	Thrush
Gull	Raven	Titmus
Hobby	Roller	Woodcock

Domestic animals were represented by the following useful inhabitants of the farmstead:

Boss	Dobbin	Jack
Bull	Dogge	Jenny
Burro	Donk	Kidde
Capon	Drake	Malkin
Catt	Filley	Mare
Cattell	Gander	Nanny
Chick	Gilt	Rabbitt
Cocke	Gosling	Shoat
Cockrell	Hogg	Steer
Colt	Hoggett	

Sixteen more mammals were trophies of the hunt:

Boy	Hind	Otter
Deer	Lemming	Panther
Elefant	Leopard	Sable
Elk	Mink	Tiger
Gibbon	Mole	
Grison	Moose	

The directories of San Francisco and Los Angeles provided the following additions to the list of anatomical terms:

Ankle	Finger	Nail
Arch	Fist	Ribbe
Arms	Gut	Sides
Back	Hair	Skinn
Bone	Hock	Teat
Bowell	Hoof	Thumb
Brow	Kidney	Thye
Cheek	Knee	Tongue
Eggs	Legge	Tooth
Eye	Maw	

Having had good hunting on the Pacific coast, I prepared for larger fields by adding to my list of unfound possibilities until it numbered about 625. Of much help were the many plants and animals illustrated in a dictionary, and I included in the list about 50 biological surnames encountered in general reading. All the latter were found subsequently in telephone directories of cities in the eastern part of the United States.

Giant among telephone directories is the Chicago book, because New York City sub-

scribers are grouped in several separate volumes based on the boroughs, and the third telephone city of the world, London, divides its directory into two volumes. From Aabad to Zyzik in the Chicago directory the distance was 1,741 four-column pages, a total column length of 6,021 feet.

From a systematic standpoint the most lowly among the surnames of plant origin in Chicago was Kelp, followed by Brake. Wild and cultivated plants, except trees, were as follows:

Aloe	Dock	Nettles
Anis	Ginger	Oats
Begonia	Gourd	Orris
Burdock	Honeysuckle	Thistle
Brier	Mallow	Tulip
Columbine	Marguerite	Violet
Caraway	Millet	Yarrow

There were 17 trees and shrubs, as well as the name Tree.

Alder	Filbert	Oak
Almond	Hazel	Olive
Birch	Hemlock	Quince
Cinnamon	Magnolia	Spruce
Cypress	Myrtle	Willow
Elm	Orange	

Names that refer to plant anatomy were:

Cedarleaf	Seed	Tuber
Peel	Straw	

Although lists already given include many fishes, there were still others in the Chicago directory:

Dolphin	Guppy	Shark
Goby	Hake	Snook
Gudgeon	Mullet	Wrasse

And still more birds:

Cardinal	Grouse	Robin
Crane	Merlin	Sora
Dipper	Owl	Snipe
Falcon	Pheasant	Teal
Flicker	Plover	Willet
Gannett	Pellican	

Among the following mammals were several additions to the list of domestic animals:

Baby	Lady	Ram
Buffalo	Lass	Stripling
Beaver	Man	Seal
Camel	Marten	Stag
Foale	Mule	Virgin
Ferret	Muskrat	Whale
Lad	Puss	

Chicago furnished additions, also, to the group of anatomical terms:

Belly	Gum	Pastern
Clawes	Heart	Quill
Fang	Heel	Rump
Feather	Kneebone	Talon
Flank	Liver	Wattles
Foot	Mane	Wool
Fin	Nape	

Following the expedition through the Chicago directory, the list of possibilities were checked through the 'phone books of Boston, Brooklyn, and Detroit. From Aaberg to Zynsky, in Boston, was a distance of 804 pages and 2,780 linear feet of columns; there were 784 pages in the Brooklyn book, from Aa to Zytynski; and the Detroit directory, from Aaberg to Zzzpt, was 910 pages in length. Trophies from all three hunts are combined in the lists which follow.

In Detroit I found Winston Churchill's famous trio of Blood, Sweat, and Tears. Other materials found in the three books were Butter, Milk, Ivory, and Breath.

The botanical names were these:

Awn	Larch	Saffron
Basil	Leaf	Savory
Belladonna	Lilac	Shamrock
Calla	Maize	Stock
Cassia	Poplar	Tea
Chicory	Raisin	Teasel

There were more fishes:

Dabbs	Goldfish	Shad
Elver	Grunt	Thresher
Gar	Lamprey	

One reptile, Blackadder, occurred.

In addition to the many species of birds recorded from directories previously examined, there were 10 in Boston, Brooklyn, and Detroit, with Brood for good measure.

Auk	Goose	Sheldrake
Bittern	Hen	Terns
Eider	Oriole	
Erne	Pullett	

A few more mammals:

Bunny	Goat	Squirrel
Ewe	Ratte	Weasel

And further anatomical names:

Antler	Ramus	Vein
Neck	Shoulder	Whisker

After having explored seven telephone directories I began to get the feel of the undertaking. A sense of the kind of words likely to be found as biological surnames had developed, so I went back over some of the indexes of botanical and zoological books.

More possibilities were obtained by scanning references on the botany and zoology of the British Isles. This was a pleasant experience because so many of the common names used in the mother country have been adopted here. On the other hand, many were wholly strange. If an American, reading about rural England, should find this statement: "Then I glimpsed an effet as it dashed from a patch of squitch and gobbled a mawk beneath a paigle," he would be confused. Having translated, he would find that a lizard had left its hiding place in couch grass (*Agropyron repens*) and eaten a maggot under a cowslip (*Primula veris*). We need to understand our neighbor's language better!

Several hundred possibilities resulted from this more effective approach. Equipped with the new list I hunted again through the telephone directories of Los Angeles, San Francisco, Chicago, Detroit, Boston, and Brooklyn. Using both lists, I then examined the Philadelphia Telephone Directory. The plants found in the seven books, omitting a number of unfamiliar ones, were as follows:

Arum	Cornel	Redwood
Balm	Crowfoot	Rosemary
Barley	Currant	Rust
Bent	Fennell	Senna
Bunt	Gale	Sorrel
Burnet	Gorse	Speedwell
Cabbage	Grape	Spelt
Calamus	Heather	Spice
Camphor	Hop	Thyme
Campion	Leatherwood	Tansy
Cane	Mayberry	Walnut
Caper	Mints	Woodbine
Celandine	Osier	Woodruff
Chives	Pear	Wormwood
Colliflower	Ramson	Yew

There were more plant parts:

Acorn	Cork	Spike
Bark	Gall	Twigg
Blossom	Pod	

Fishes were represented by:

Barbel	Grindle	Pogge
Brill	Gunnell	Ruffe
Burbot	Mackerell	Smolt
Cisco	Minnow	Sparling
Dace	Molla	Shiner
Flounders	Parr	
Fry	Pilchard	

Two of the surnames found were transfers from the names of amphibians: Asker, Eft. Three reptiles, Boa, Luth, and Serpente, were discovered.

Birds and their parts were as follows:

Biddy	Combs	Pinnock
Bill	Down	Pippitt
Bulfinch	Hummer	Spurr
Canary	Macaw	Tit
Chaffinch	Ortolan	Web
Chat	Peregrin	

Mammals and their structures were:

Body	Gazelle	Pore
Bruin	Goa	Roebuck
Chest	Hock	Tabby
Craw	Kitt	Wethers
Ermine	Knuckles	Withers
Farrow	Leverett	Wrinkle
Fleece		

Every collector at length awakens from his self-induced trance to admit a need for setting a limit to his enterprise. So, after Philadelphia, I decided to use the two long lists only once more, in London. But I couldn't drop certain unfound probabilities. Therefore I made a list of about 50 choice ones and set out to find them in the directories for Baltimore, Bronx, Cleveland, Houston, Long Beach, Manhattan, Milwaukee, Minneapolis, Newark, New Orleans, Portland (Oregon), Queens, St. Louis, San Diego, Seattle, and Washington. There were satisfactions in this search, since most of the surnames that turned up may be considered to be rarities. First, the plants, the last one being more recent than most biological surnames:

Bellrose	Scallion	Tobacco
Parsnip		

There was one fish, Girling (a young salmon), as well as several other vertebrates:

Chicken	Mouse	Pups

And some interesting anatomy:

Breast	Flesh	Nipple
Face	Hips	Tissue

Examination of the London Telephone Directory, of 2,209 three-column pages, from Aaggard to Zyrot, followed. I was in effect searching the "mother lode," the original source from which family names of English-speaking people have been scattered over the world. None of the following had been found in American lists.

Botanical surnames were:

Daphne	Majoram	Spurge
Iris	Madder	Sycamore
Lupine	Mold	Vetch

And, as always, a few additions to the long list of fishes:

Gargett	Flaice	Smelt
Grayling	Pout	Sucker

One amphibian, Newte, and three birds:

Condor	Gooney	Phoebe

The list of mammals included several of the few names of domesticated animals that had not been located before:

Boar	Girle	Stallion
Calf	Lynx	Stoat
Cow	Marmot	Voles
Gelding	Ox	

Anatomical terms were Beak, Chine, Hide, Skinn, Skull, Toe, and Wrist.

Invertebrates found in all directories are combined in a single list, which includes a few surnames associated with parts or products of backboneless animals.

Ant	Grubbs	Pupa
Barnacle	Honey	Scallop
Bee	Hornett	Shell
Beetle	Leach	Silk
Bot	Locust	Slug
Bug	Looper	Spider
Clam	Maddock	Sting
Cockle	Mantis	Tick
Coral	Moths	Warble
Crabb	Mussel	Wasps
Cricket	Oyster	Wax
Drill	Pearl	Winkle
Goldflies	Piddock	Worm

In the course of the investigation I recorded a number of surnames which have their origin in mythological persons and beasts:

Angel	Fairy	Indra
Atlas	Faun	Merman
Cherubin	Fay	Phoenix
Dragon	Genius	Satyr
Elf	Griffin	

Not so much mythological as fictional, Doe (John) and Roe (Richard), long prominent in the symbolism of the law, both refer to names of deer. Other imaginary persons were Punch and Judy.

Even after the good returns from my hunt through the London books, I was not satisfied. Missing were many surnames that could have escaped transfer from the names of common living things only by some improbable accident. I had located more than 300 fishes, amphibians, reptiles, birds, and mammals, but where were Donkey, Heifer, Hinny, Horse, Sheep, Toad, and Woman? About 100 family names were based on animal structures, but why had Jowl, Stomach, and Tail eluded search? Plant surnames to the number of about 200, not to mention some 35 terms for plant parts, had turned up, but not Lentil and Turnip. A fair representation of the small but useful invertebrates did not include the superlatively toothsome Lobster.

Are some of the "lost" families still occupying the same English farms where their family trees became established hundreds of years ago? Perhaps certain of the male lines have run out, or other names have been chosen. Possibly some are living in the United States outside of large cities. They may have no telephones. Some of them may be living in other countries.

According to an analysis of surnames recorded during the first United States Census,[2] the following families which I have been unable to find in telephone books were living in this country in 1790:

Bantam	Horse	Sealion
Heifer		

It is of interest to record that surnames found in the course of the First Census were 83.5 percent English and 91.8 percent from the British Isles.

In a final effort to find Horse, Sheep, and Turnip I looked in the telephone directories of Atlanta, Buffalo, Cincinnati, Columbus, Dallas, Dayton, Denver, Fort Wayne, Fort Worth, Indianapolis, and Pittsburgh; Montreal, Toronto, and Van-

[2] *A century of population growth.* From the First Census of the United States to the Twelfth, 1790–1900. U. S. Department of Commerce and Labor, Bureau of the Census. 303 pp., 1909.

couver, Canada; Melbourne and Sidney, Australia. Although the Turnipseed family is well distributed, Turnip still eluded me. I could get no closer to Horse than Horsey, which occurs plentifully. But I found Sheep. That is my *rara avis;* or, more accurately, *rara ovis!*

Those who write reports of the results of their research seldom mention one influence that helps to shape the course of their endeavors. I refer to the comments of wives. In my case attention was called to the possibility of sometime bringing the search to a close by a gentle remark, "I'm getting a little tired of seeing piles of telephone books around the house."

BOTANY.—*New species of trees from western Ecuador.*[1] ELBERT L. LITTLE, JR., Forest Service, U. S. Department of Agriculture.

The 19 new species here described and illustrated are from the author's collection of tree specimens made in 1943 in western Ecuador with the Latin American Forest Resources Project of the U. S. Forest Service. Genera represented are: *Heisteria, Hirtella* (2), *Brownea* (3), *Humiria, Erythrochiton, Tetragastris, Guarea, Trichilia, Belotia, Matisia* (2), *Clusia* (2), *Neosprucea, Symplocos,* and *Aspidosperma.* Twelve species are from the province of Esmeraldas, and others from the provinces of Pichincha, Chimborazo, Los Ríos, and El Oro. Additional new species from this collection are being published elsewhere by specialists, and others must remain undescribed at present because of incomplete material.

Type specimens have been deposited in the U. S. National Herbarium, Washington, D. C., and a set of isotypes in the herbarium of the U. S. Forest Service, Washington, D. C. Additional isotypes of most species are in the following herbaria: Tropical Forest Experiment Station, U. S. Forest Service, Río Piedras, Puerto Rico; Yale University School of Forestry, New Haven, Conn.; Chicago Natural History Museum, Chicago, Ill.; and Instituto Botánica, Universidad Central, Quito, Ecuador.

Acknowledgment is due C. V. Morton, of the U. S. National Museum, for assistance in checking the Latin diagnoses, to Ellsworth P. Killip, also of the National Museum, for suggestions, to Miss Leta Hughey, botanical artist, Forest Service, for making the drawings of the new species, and the late Dean Samuel J. Record, Yale University School of Forestry, for making generic determinations of wood samples of four of these new species. The Forest Service project in Ecuador is described in the following report: HOLDRIDGE, L. R., et al., *The forests of western and central Ecuador.* 134 pp., illus. Forest Service, U. S. Dept. Agr., Washington, D. C. 1947. (Processed.)

Heisteria cyathiformis Little, sp. nov.

Fig. 7

Sec. *Euheisteria* Engl. Frutex vel arbor parva 4 m alta, trunco 3 cm diametro, glabra, ramulis gracilibus teretibus viridulis, novellis subangulatis, internodiis brevibus 0.5–3 cm longis. Folia petiolata, petiolis 4–11 mm longis, supra leviter canaliculatis; laminae anguste ellipticae vel oblanceolatae, (5) 8–15 cm longae, 3–5.5 cm latae, basi acutae vel acuminatae, apice subabrupte acuminatae, acumine 4–9 mm longo, membranaceae, margine integrae, costa supra plana subtus elevata, nervis lateralibus utrinque 5–9, prope marginem arcuato-conjunctis, subtus prominulis. Flores fasciculares in axillis 2 vel 3; pedicellus 3 mm longus, apicem versus crassus; albastrum ca. 1.5 mm longum; calyx 1 mm longus ad medium 5-lobus, lobis triangularibus acutis; corolla in alabastro globosoellipsoidalis, 1.3 mm longa, viridulo-albida, 5-lobata, intus minute puberulenta; stamina 10, 5 longiora et 5 alternatim breviora; ovarium triangulare, apicem versus acuminatum, 1 mm longum, 1 mm diametro, 3-loculare ovulis 3, stigmate minuto sessili 3-lobato. Fructus solitarius, pedicello in stato fructifero 12–15 mm longo, calyce fructifero accrescente cyathiformi, 4–5 mm longo et 7 mm lato, truncato, subintegro vel minute 5-dentato, rubro; drupa ellipsoidalis, 11 mm long, 7 mm diametro, nigra.

Shrub or small tree 4 m tall and 3 cm in trunk diameter, said to become larger. Speci-

[1] Received October 3, 1947.

mens collected from two plants in wet tropical forest at Quinindé. "Aji."

Esmeraldas: Quinindé, altitude 65 m, April 15, 1943, *Little 6263A* (Forest Service no. 96832; U. S. Nat. Herb. no. 1854915, TYPE). *Little 6263* (Forest Service no. 96833).

Heisteria Jacq. has more than 40 species in South and Central America and 3 in western Africa. Most species have the enlarged calyx of the fruit lobed and rotate, reflexed, or loosely enclosed the drupe. In *H. cyathiformis* the red, cup-shaped or hemispherical calyx is about one-third the length of the black, ellipsoidal drupe (red when immature) and closely adheres to the lower part of the drupe. This enlarged fruiting calyx is truncate and subentire or minutely 5-toothed. Superficially the fruit, with its elongated drupe and cuplike calyx, resembles that of some members of the Lauraceae, though the other characters are unlike that family. Caroline K. Allen and I. W. Bailey kindly have suggested that this material probably belongs in *Heisteria*, where it apparently is undescribed.

Heisteria cyathiformis is related to *H. cyanocarpa* Poepp. & Endl., of the Amazonian region of Brazil, Peru, and Ecuador, which has larger and thicker leaves, more flowers in a fascicle, and the fruiting calyx broad, orbicular, usually reflexed. The collection contains material of another species of this genus, doubtfully referred to the Central American species *H. macrophylla* Oerst.

Hirtella carbonaria Little, sp. nov.
Fig. 3

Arbor mediocris 12 m alta, trunco 25 cm diametro. Cortex laevis, griseus. Ramuli parce hirsutuli mox glabrescentes. Folia petiolata cum stipulis linearibus, ca. 3 mm longis, involutis, strigosis; petiolis ca. 2 mm longis, parce hirsutulis; laminae ellipticae, 5–9 cm longae et 2.5–4 cm latae, basi rotundatae, apice abrupte acuminatae, integrae, inflexae, coriaceae, reticulatae, supra glabrae, subtus in costa et venis pilis paucis subappressis praeditae, venis primariis 5–8-jugis, arcuatis et margine anastamosantibus, his cum costa utrinque paullo elevatis. Inflorescentiae terminales atque axillares, thyrsiformes, multiflorae, cum floribus multis abortivis, 6–9 cm longae et 2–4 cm latae, pedunculo 2–5 cm longo, rhachibus pilos paucos appressos gerentibus; bracteae triangulares, acutae, 1–2 mm. longae; pedicelli 3 mm longi; hypanthium campanulatum, 3 mm longum et 2 mm latum, externe sparse pubescens, intus glabrum; sepala 5, elliptica, obtusa, 3 mm longa et 2.5 mm lata, externe strigillosa, intus densius strigillosa; petala 5, alba, elliptica, 4 mm longa et 2.5 mm lata, retusa, glabra; stamina 3, 8–12 mm longa, filamentis glabris, basi connatis; staminodia 2, 1.5 mm longa; ovarium fere 2 mm longum, dense pilosum; stylus deorsum sparse pilosus, 10–15 mm longus. Drupa obovoidea, 15 mm longa, 8 mm lata, 3.5 mm crassa, compressa, atra, glabrescens, intus dense pilosa; semen ellipsoideum, compressum, fuscum, ca. 10 mm longum, 5 mm latum, 2.5 mm crassum.

Medium-sized tree to 12 m tall and 25 cm in trunk diameter. Bark smooth, gray. Wood used for charcoal, as the common and specific names indicate. Common in moist soil, flood plain forest near Río Nadadero, wet tropical forest zone at San Lorenzo. "Carbonero," "carboncillo."

Esmeraldas: San Lorenzo, altitude near tidewater, April 19, 1943, *Little 6275* (Forest Service no. 96790; U. S. Nat. Herb. no. 1858838, TYPE).

Besides *Hirtella triandra* Sw., this collection contains two undescribed species of *Hirtella* L. *Hirtella carbonaria* has elliptic, coriaceous, glabrescent leaves that are turned inward slightly at the midrib. The pubescence of twigs, leaves, and inflorescence is rather sparse, consisting generally of a few appressed hairs, which are lost as the parts become nearly glabrous with age. The thyrsiform inflorescence contains many abortive flowers.

Hirtella pauciflora Little, sp. nov.
Fig. 2

Arbor magna 25 m alta, trunco 50 cm diametro. Cortex laevis, leviter fissilis, fuscus. Ramuli dense hirtelli. Folia petiolata cum stipulis linearibus, ca. 3 mm longis, dense hirtellis; petiolis 3–4 mm longis, dense hirtellis; laminae ellipticae, 7–13 cm longae et 3–5 cm latae, basi acutae, apice acuminatae, integrae, membranaceae, pallide virides, supra costis hispidae, pilis paucis rigidis in venis et venulis ferentes, mox glabratae, subtus in venis et venulis hispidae, nervis primariis 6–9-jugis, ascendentibus, his cum costa supra leviter impressis, subtus prominentibus. Inflorescentiae

FIG. 1.—*Belotia australis*, $\frac{1}{3}\times$; flower, $2\times$; fruits, $\frac{2}{3}\times$. FIG. 2.—*Hirtella pauciflora*, $\frac{1}{3}\times$; flower, $2\times$. FIG. 3.—*Hirtella carbonaria*, $\frac{1}{3}\times$; flower, about $3\times$; fruit, $\frac{4}{3}\times$. FIG. 4.—*Guarea polymera*, $\frac{1}{3}\times$; flower, $1\times$; fruit, $1\times$.

racemosae terminales in ramulis brevibus, inconspicuae, 2- vel 3-florae, 3–6 cm longae, pedunculo hirtello, 1–4 cm longo; pedicelli crassi, inflati, lignei, 10–12 mm longi, basi fere 1 mm diametro, medio et apice 1.5–2 mm diametro, dense hirtelli; flores viridulo-fusci, ca. 5 mm longi et 5 mm diametro; hypanthium ca. 2 mm longum et 2 mm latum, externe hirtellum, intus fauce dense retrorse pilosum, alibi glabrum; sepala 5, late elliptica, obtusa, 3 mm longa et 2–3 mm lata, externe dense hirtella, intus dense puberula; petala 5, elliptica, obtusa vel retusa, 3 mm longa et fere 2 mm lata; stamina 3, filamentis glabris, basi connatis, 5–7 mm longis; staminodia 2, minuta, 0.2 mm longa; ovarium fere 2 mm longum, dense pilosum; stylus basin versus sparse pilosus, alibi glaber, 4 mm longus. Fructus deest.

Large tree 25 m tall and 50 cm in trunk diameter. Bark smooth, slightly cracked, brown. Virgin wet tropical forest and old cacao plantation at Pichilingue. "Coquito."

Los Ríos: Pichilingue, altitude 45 m, May 21, 1943, *Little 6475* (Forest Service no. 95855; U. S. Nat. Herb. No. 1876218, TYPE).

The inconspicuous, small racemes terminal on short branches and bearing only 2 or 3 flowers distinguish *H. pauciflora*.

Brownea disepala Little, sp. nov.
Fig. 9

Arbor magna 30 m alta; trunco 35 cm diametro, florifero, cum tumoribus ellipsoidalibus magnis et conspicuis, 3–5 cm crassis, 3–5 cm longis, et 3–10 cm latis, cicatricibus inflorescentiarum ferentibus. Cortex griseus, fere laevis; ramuli glabri. Folia paripinnata; petioli crassi, subglabrati, 6–15 mm longi et 3–4 mm diametro; rhaches 20–40 cm longi, fere glabri; petioluli crassi, corrugati, 3–5 mm longi, subglabri; foliolae (4) 6–9-jugae, oppositae, oblongo-ellipticae, (5) 9–12 cm longae, (2) 3–4 cm latae, basi inaequales, apice longe caudato-acuminatae, subcoriaceae, nitidae, reticulatae, glabrae, costae basi glande uno minuto gerentes. Inflorescentia caulina capitata, strobiliformis, globosa, sessilis, pallide incarnata, 5 cm diametro; bracteae multae, subrotundae vel ovatae vel oblongae, valde concavae, 1–7 cm longae, externe dense tomentosae, intus glabrae vel leviter pilosae, exteriores satis crassae et coriaceae, interiores membranaceae; rhachis 2.5–3 cm longa et 8–10 mm diametro, ad $\frac{2}{3}$ longitudinis bracteata, apicem versus florifera. Flores multi (ca. 30–40), albidi; pedicelli 10–18 mm longi, pilosuli; vagina nulla; hypanthium campanulatum, subtetragonum, 8 mm longum, 5–6 mm latum, pilosulum; sepala 2, oblanceolata vel oblonga, apice bidentata dentibus 3–5 mm longis, pilosula vel glabrata, nervis parallelis, 30–50 mm longa et 10–15 mm lata; petala 4, longe angusteque unguiculata, glabrata, pinninervia, 2 majora oblanceolata, obtusa, 37–43 mm longa et 10 mm lata, 2 minora lineari-spathulata, acuta, 25–27 mm longa et 3 mm lata; vagina staminalis 3 cm longa, pilosula; stamina 17 vel 18, filamentis 25–50 mm longis, antheris 5–6 mm longis; ovarium stipitatum (6 mm), 15 mm longum, 2.5 mm latum, compressum, dense tomentosum; stylus glaber, 50–60 mm longus; stigma capitellatum. Legumen paucum, ca. 15 cm longum, 4 cm latum, plano-compressum, rufopuberulum, valvis post dehiscentiam tortuosis.

Large tree 30 m tall and 35 cm in trunk diameter, distinguished by cauliflory. Bark gray, smoothish. Trunk easily recognized by the enlarged elliptical swellings at scars of former inflorescences. The large whitish flowers are borne in a headlike cluster from a spherical pink, bracteate, strobiliform bud about 5 cm in diameter which is sessile on the trunk. From the flower cluster a few large flat pods develop. Mountain (wet tropical) forest in southwestern Ecuador. "Palo de vaina."

El Oro: Near Piedras, altitude about 800 m, June 21, 1943, *Little 6677* (Forest Service no. 98587; U. S. Nat. Herb. no. 1857106 and 1857107, TYPE). Guayas: Near Pedro Carbo, altitude about 300 m, Jan. 13, 1943, *Oscar Haught 3131* (U. S. Nat. Herb.).

Haught 3131 has flowers similar to those of the type but differs in having the leaflets slightly smaller (5–7 cm long and 2–2.5 cm broad). It is described by the collector as a moderate-sized tree, strictly cauliflorous, with white flowers, in a forest on calcareous soil.

The genus *Brownea* Jacq. contains more than 25 known species, principally from Venezuela, Colombia, and Peru, with more from Venezuela than any other country. Some species occur also in Panama, the Guianas, and Brazil. Many of these are of restricted distribution. Only one new species, *B. herthae* Harms, has heretofore been described from Ecuador. In addition to that species, this collection contains

FIG. 5.—*Brownea angustiflora*, $\frac{1}{3}\times$; flowers, about $\frac{3}{4}\times$. FIG. 6.—*Tetragastris varians*. $\frac{1}{3}\times$; flower, $4\times$. FIG. 7.—*Heisteria cyathiformis*, $\frac{1}{3}\times$. FIG. 8.—*Brownea puberula*, $\frac{1}{3}\times$.

three new species of *Brownea*. Most species of *Brownea* have very showy, brilliant red flowers borne in terminal inflorescences. Very few species have white flowers and very few have cauliflory. *Brownea disepala* is odd in both ways in having white flowers borne in clusters on the trunks.

The segregate genus *Browneopsis* Huber (Bol. Mus. Goeldi **4**: 565. 1906) was proposed for the species with sheath absent, larger number of stamens, and lesser development of petals (lacking, rudimentary, or 4). However, Ducke, Record and Hess, and Macbride have reduced the segregate to synonymy. Besides *Brownea disepala*, other species in this group are: *Brownea ucayalina* (Huber) Ducke, *Brownea cauliflora* Poepp. & Endl., *Brownea excelsa* (Pittier) Macbr., and *Brownea peruviana* Macbr. Of these, the new species is like the last in its calyx. Macbride (Field Mus. Bot. **13**, pt. 3, no. 1: 134–135, 132. 1943) in the original description noted that *B. peruviana* was aberrant in having 4 petals and 2 colored, petaloid bractlets or sepals. After examining a specimen of one of the two collections cited by Macbride (*Klug 3810*), I interpret as sepals the two parallel nerved structures of both species attached in the usual position of the calyx, at the summit of the hypanthium and outside the four clawed, pinnately nerved petals. These sepals, which in both species are slightly 2-toothed or 2-lobed at the apex, may represent a reduction from 4 sepals to 2 connate ones. This interpretation is simpler than the alternate one also mentioned by Macbride of regarding the petals as absent, the 4 clawed petaloid structures as bractlets. In *Brownea* the bractlets or sheath, when present, are attached at the base of the hypanthium, not at the summit.

Brownea puberula Little, sp. nov.

Fig. 8

Arbor 6 m alta vel major, trunco 10 cm diametro. Ramuli, petioli, rhaches, et petioluli dense et minute fusco-puberuli vel demum glabrati. Folia paripinnata; petioli basi crassi, 5–40 mm longi; rhaches (3) 7–25 cm longae; petioluli 3–7 mm longi; foliolae (1) 3–7-jugae, oppositae, oblongo-ellipticae vel ovatae, (4) 7–12 cm longae, (2) 3–6 cm latae, basi inaequales, obtusae vel rotundatae, apice longe caudato-acuminatae (1.5–2.5 cm longa), coriaceae, supra glabrae, subtus minute puberulae, reticulatae, costae basi glande uno gerentes. Inflorescentiae terminales vel laterales, interdum ex rhachibus inflorescentiarum priorium; racemi breves, umbelliformes, rhache 2 cm longa, bracteis caducis; flores 15–25, rubri vel coccinei, spectabiles; pedicelli tenues, puberuli, 10–20 mm longi; vagina petaloidea tubulosa, bilabiata, 30–32 mm longa, externe appresso-puberula, intus glabra, lobis acutis 10–12 mm longis; hypanthium anguste tubulosum, 12–14 mm longum, 3 mm diametro, puberulentum vel glabratum; sepala 4, petaloidea, glabra, 24–27 mm longa, anterius obovatum, acutum, 8–11 mm latum, alia oblanceolata, obtusa, 4–6 mm lata; petala 5, fere aequalia, 37–46 mm longa, 9–13 mm lata, longe angusteque unguiculata, glabra, obovata, obtusa; stamina 11, 38–45 mm longa, ad $\frac{1}{2}$ vel $\frac{2}{3}$ longitudinis connata; vagina staminalis externe glabra, intus basi pilosa; filamentis glabris, 10–18 mm longis; antheris 2 mm longis; ovarium 7–8 mm longum, dense tomentosum; stylus tenuis, deorsum tomentosus, 27–35 mm longus; stigma capitellatum. Legumen 20 cm longum, 4.5 cm latum, planocompressum, minute fusco-tomentosum, valvis post dehiscentiam tortuosis.

Tree 6 m tall and 10 cm in trunk diameter. Uncommon in understory of wet, swampy tropical forests at sea level, including flood plain at edge of river and higher level of mangrove swamp forest at San Lorenzo.

Esmeraldas: San Lorenzo, sea level, April 22, 1943, *Little 6338* (Forest Service no. 98230; U. S. Nat. Herb. no. 1909574, type); April 22, 1943, *Little 6338A* (Forest Service no. 98231); April 19, 1943, *Little 6291* (Forest Service no. 96719). Province not known: Moist forest at foot of Western Cordillera, altitude 200 m, *Rimbach 183* (U. S. Nat. Herb.).

Rimbach 183, from an inland locality, was described by the collector as a tree 20 m high and 25 cm in trunk diameter, with red flowers in dense umbels, mostly from old wood, sometimes near base of trunk, and more rarely from the branches.

This species is unusual in the dense, minute, dark brown pubescence of the young branches, petioles, rachises, and petiolules. However, in age the pubescence may be nearly absent. The inforescences are fewer flowered and the flowers more nearly glabrous than in most species of *Brownea*. Though it has the bilabiate floral

sheath found in most species of the genus, *Brownea puberula* is distinct in the size, shape, and pubsecence of the floral parts. It resembles *B. birschellii* Hook. f., of Venezuela, which is glabrous and has much larger clusters of larger flowers. In publishing that species, J. D. Hooker (Bot. Mag. **98**: *pl. 5998.* 1872) mentioned that "it closely resembles a species from the Pacific sea-coast of New Granada, at Esmeraldas, collected by Colonel Hall, and preserved in the Hookerian Herbarium." Hall's specimen, collected near the type locality of *B. puberula*, upon examination may prove to be a much earlier collection of this species.

Brownea angustiflora Little, sp. nov.
Fig. 5

Arbor parva 10 m alta, trunco 15 cm diametro. Ramuli glabri. Folia paripinnata, glabra; petioli basi crassi, 4–25 mm longi; rhaches 3–15 cm longae; petioluli 3–5 mm longi; foliolae 2- vel 3-jugae, oppositae, oblongo-ellipticae, (7) 10–23 cm longae, (3) 4–7 cm latae, basi inaequales, obtusae vel acutae, apice caudatoacuminatae (1–3 cm longo), coriaceae, reticulatae, costae basi glande uno gerentes. Inflorescentiae terminales et laterales vel caulines; racemi breves, umbelliformes, rhache 1.5–2 cm longa, bracteis caducis; flores ca. 15–20, rubrae vel coccineae, spectabiles; pedicelli tenues, puberuli, 9–12 mm longi; vagina petaloidea, anguste tubulosa, 35–52 mm longa, 6 mm diametro, uno latere ad 15–20 mm fissa, externe puberula, intus glabra; hypanthium anguste tubulosum, 11–15 mm longum, 2–2.5 mm diametro, glabrum; sepala 4, petaloidea, glabra, anterius oblanceolatum, acutum, 35 mm longum et 6–7 mm latum, alia linearia, acuta, 28–30 mm longa et 2–3 mm lata; petala 5, longe angusteque unguiculata, glabra, maximum oblanceolatum, retusum vel apiculatum, 42 mm longum, 6–8 mm latum, duo oblanceolata, retusa, 35–38 mm longa, 4–6 mm lata, duo linearia, obtusa, 20–22 mm longa, 1–2 mm lata; vagina staminalis 25–29 mm longa, glabra vel leviter pilosa; stamina 9 vel 10, filamentis 10–20 mm longis, antheris 2 mm longis; ovarium 9–10 mm longum, 2 mm latum, dense tomentosum; stylus tenuis, inferne tomentosus, 35–40 mm longus; stigma capitellatum. Legumen paucum, 20 cm longum, 4 cm latum, planocompressum, minute puberulum; valvis post dehiscentiam tortuosis; semina orbiculata, plana, 2.5 cm diametro.

Small tree 10 m tall and 15 cm in trunk diameter, in understory of wet tropical forest and in clearing. "Flor de mayo."

ESMERALDAS: Borbón, elevation 15 m, May 3, 1943, *Little 6418* (Forest Service no. 98232; U. S. Nat. Herb. no. 1879851, TYPE); April 26, 1943, *Little 6382* (Forest Service no. 98225).

Two collections of this species were made, both at the same locality. In the type collection, *Little 6418*, the inflorescences are terminal or lateral on the leafy branches. *Little 6382* has the flowers borne on the trunk and slightly larger and more mature.

This species is characterized by long, narrow, slender, nearly glabrous flowers in few flowered clusters. The narrowly tubular flower sheath, which is cleft on one side, is unusually long, 35–52 mm long, and nearly encloses the perianth, though the three larger petals are exserted. The sheath generally varies from 12 to 32 mm long in other species of *Brownea*. Only a few others, such as *B. coccinea* Jacq. and *B. aroensis* Pittier, have the sheath cleft on only one side instead of bilabiate.

Humiria procera Little, sp. nov.
Fig. 12

Arbor magna recta, 30–34 m alta vel major. Ramuli glabri, 4-alati ex foliis et costis decurrentibus, alis 1–2 mm latis. Folia disticha, decurrentia, sessilia, coriacea, vivo atroviridia, nitida, late elliptica, 8–13 cm longa et 5–7 cm lata, basi obtusa, apice abrupte et breviter acuminata (5–10 mm), margine remote glanduloso-crenulata, supra glabra, subtus minute rugulosa, costa subtus carinata, carina angusta, basi 1 mm alta, decurrente. Inflorescentia axillaris, corymbosa multiflora, 4–6 cm longa et 3–5 cm lata, puberula, ca. 5 vel 6 dichotoma vel trichotoma; bracteae triangulares, acutae, 1–2 mm longae; pedunculus alatus anceps, 2–2.5 cm longus; pedicelli 1 mm longi; flores minuti, viriduli, ca. 2 mm longi et 1.5 mm lati; sepala 5, rotundata, ciliata, leviter puberula, 1 mm longa; petala 5, oblonga, externe leviter puberula, 1.5–2 mm longa et 0.5 mm. lata; stamina 20, glabra, ca. 1.5 mm longa; filamenta basi connata; cupula hypogyna e squamis plus minus connatis composita; pistillum ca. 1.5 mm longum; ovarium ovoideum, parce puberulum, 5-loculare, ovulis 2 in loculo;

stylus crassus; stigma 5-radiatum. Drupa ovoidea vel ellipsoidea, base obtusa, apice acuta vel obtusa, tomentosa, 25–35 mm longa, 17–20 mm lata; endocarpium osseum, sub apice 5-foveolatum.

Large erect tree of forest canopy in wet tropical forest, 30 to 34 m tall and 40 cm in diameter, according to measurements from trees felled for wood samples, but becoming larger. The fruits resemble pecans (*Carya illinoensis* (Wangenh.) K. Koch) in size and shape. It is said that the oily seeds are edible. "Chanul."

ESMERALDAS: Playa de Oro, altitude about 65 m, May 1, 1943, *Little 6412* (Forest Service no. 95906; U. S. Nat. Herb. no. 1876214, TYPE; with wood sample). *Little 6413* (Forest Service no. 95907; with wood sample). San Lorenzo, altitude about 10 m, April 21, 1943, *Little 6320* (Forest Service no. 96880; with wood sample). Quinindé, altitude 65 m, April 9, 1943, *Little 6233* (old fruits only).

Common and probably widely distributed in the wet tropical forest of Esmeraldas. In some locations near San Lorenzo it comprises a large part of the big timber. Very common also along the banks of Río Santiago above Selva Alegre, where Chanuzal, a group of houses, apparently derives its name from the many trees of "chanul." After partial cutting of other tree species, "chanul" occurs in nearly pure stands. It exists in quantities along the main rivers and trails.

The South American genus *Humiria* Jaume St.-Hil. is distributed in Brazil, the Guianas, Venezuela, and Colombia and apparently has not been reported previously from Ecuador. Though the characteristic size is that of shrubs and small trees, two species are described as becoming large trees under favorable conditions. Selling (Svensk Bot. Tidskr. **39**: 257–269, illus. 1945) distinguished 6 living species and 3 fossil ones. The latter, based upon fruits from Brazil, Colombia, and Peru (Piura), indicated a broader distribution of the genus in the Tertiary than at present.

Wood samples of the Ecuadorian material were first determined by S. J. Record as *Humiria* sp. near *H. floribunda* Mart., which occurs in the Guianas, Amazonian Brazil, Venezuela, and Colombia. Subsequent study of herbarium specimens confirmed this determination and showed that an undescribed species was represented. *Humiria procera* is readily separated from other species of the genus by the numerous minute flowers only about 2 mm long, while the others have fewer, larger flowers usually about 4–5 mm long. In *H. procera* the twigs are prominently 4-winged and the leaves are distichous, abruptly acuminate, and crenulate, while in *H. floribunda* the twigs are only slightly winged, the leaves spirally arranged, smaller, usually obtuse at apex, and entire or nearly so. The distichous leaves distinguish *H. procera* from most species of the genus also.

The following notes on the wood of *Humiria procera* were made by J. Edson Myer, of the Forest Service field party. Sapwood grayish white, about 5 cm thick. Heartwood dull red, becoming brownish on exposure, hard and heavy, having a specific gravity of 0.68 based upon volume when green or 0.82 based upon volume when oven dry. Texture fine and uniform. Growth rings are indistinct due to fewer pores in denser zones; the pores are minute, thin walled, and numerous. The rays are very fine, not visible on cross section and low and inconspicuous on radial section. Wood fairly difficult to cut, rather harsh, readily polished, strong but brittle, and of medium durability. Not used much because of alleged silica content which dulls saws. Might be used for construction where not exposed to the weather.

Waterman (Trop. Woods **88**: 1–11. 1946 (1947)) included wood samples of the collections cited above in tests of decay resistance of water-soluble extractives of several tropical American woods to growth of wood-decay fungi. This species, listed as *Humiria* sp., was found to be nontoxic or not resistant to decay.

Erythrochiton carinatus Little, sp. nov.
Fig. 14

Sect. *Toxosiphon* (Baill.) Engl. Frutex vel arbor parva 2–5 m alta, trunco 5 cm diametro. Cortex griseus, leviter asper et fissilis, decorticans. Folia solitaria, unifoliata; petioli (2) 4.5–7 cm longi, 1.5 mm diametro, glabri, tenues, semiteretes, apice tumido-articulati; laminae oblongo-ellipticae, 11–20 cm longae et 5–8 cm latae, basi cuneatae, apice abrupte acuminatae, integrae, papyraceae, glabrae, inconspicue glanduloso-punctatae, venis lateralibus primariis ca. 12–14, angulo obtuso egredientibus, arcuatis, venulis reticulatis. Inflores-

FIG. 9.—*Brownea disepala*, $\frac{1}{4}\times$; axis of old inflorescence, $\frac{1}{2}\times$; young globose, unopened inflorescence, $\frac{1}{2}\times$; flower, $\frac{1}{2}\times$. FIG. 10.—*Trichilia floribunda*, $\frac{1}{4}\times$; bud, $6\times$; flower, $6\times$.

centia terminalis, 17–19 cm longa, longepedunculata; pedunculus 11–15 cm longus, sulcatus, strigillosus, apice furcatus, ca. 3-florus; flores desunt. Sepala libera, persistentia, bracteiformia, viridia, lanceolata, acuminata, reticulata, inconspicue glanduloso-punctata, externe fere glabra, intus dense tomentulosa, in fructu 30–37 mm longa et 4–8 mm lata, capsulis subduplo longiora; capsula fere ad medium 5-lobata, pallide viridis, 15 mm alta et ca. 20 mm lata, coccis 5, reticulatis, inconspicue glanduloso-punctatis, puberulis, ca. 15 mm altis et 9 mm latis, carina prominente 1–2 mm lata, mucrone 1 mm longo; semina 2, superposita, fusca, fere laeve, 5 mm longa et 4 mm lata et crassa.

Shrub or small tree 2 to 5 m tall and 5 cm in diameter. Bark gray, slightly rough and fissured, shredding. Common locally in understory of mountain (wet tropical) forest. "Chumi."

El Oro: Piedras, altitude about 500 m, June 18, 1943, *Little 6632* (Forest Service no. 98509; U. S. Nat. Herb. no. 1909573, type).

The genus *Erythrochiton* Nees & Mart. contains seven previously described species of shrubs or small trees widely but sparingly distributed in tropical America from southern Mexico to Colombia, Brazil, and Peru. Engler (in Engler and Prantl, Natürl. Pflanzenfam. ed. 2, **19a**: 288. 1931) listed five species, and two others have been added. Apparently this genus has not heretofore been reported from Ecuador. Specimens of both *Erythrochiton brasiliensis* Nees & Mart. and this new species were collected near Piedras, El Oro.

Erythrochiton carinatus belongs to Section *Toxosiphon* (Baill.) Engl., in which the 5 sepals are free, and is distinguished in fruit from the other four species of this section by the elongate, acuminate sepals about twice the length of the capsule and by the deeply lobed capsule, with a prominent keel on each segment.

Tetragastris varians Little, sp. nov.

Fig. 6

Arbor 25 m alta, trunco 50 cm diametro. Ramuli crassi, subteretes, brunnescentes, glabri, lenticellis elevatis. Folia alterna, pinnata, apicem ramulorum versus trifoliolata vel unifoliolata, petioli 4–9 (21) cm. longi, evidenter sulcati, subancipites, glabri, supra plani; rhaches foliorum trifoliolatorum 2–4 cm longae, sulcatae, glabrae, supra planae; petioluli 2–4 mm longi; laminae foliolarum late ellipticae ad obovatae, 9–20 cm longae et 5–10 cm latae, basi obtusae vel cuneatae, apice abrupte acuminatae (5–10 mm), chartaceae, integrae, venis primariis utrinque latere ca. 9–12, angulo lato divergentibus, arcuatis et prope marginem anastomosantibus, utrinque venis et venulis elevatis et prominente reticulatis, supra glabrae, subtus glabratae, minute papillosae, ad costam pilis paucissimis appressis praeditae. Paniculae laterales apicem ramulorum versus, 7–12 cm longae, multiflorae; rhaches leviter compressae, minute strigillosae, bracteatae; bracteae triangulares, acutae, 1 mm longae; pedicelli 0.5–1 mm longi; flores 4-meri (raro 5-meri), 4.5–5 mm longi; calyx 2.5 mm longus et 3 mm latus, glaber, lobis 3 vel 4, triangularibus, acutiusculis, 1–1.5 mm longis, corolla anguste campanulata, 4.5–5 mm longa, externe minute strigillosa, intus glabra, ad medium in lobis 4 (raro 5) divisa, lobis lanceolatis, 2.5 mm longis et 1 mm latis, acutis, valvatis, carinatis, crassis, marginibus apiculoque inflexis; stamina 8 (raro 10), sub disco inserta, 1.5 mm longa, glabra, antheribus 1 mm longis; discus annularis, 0.7 mm longus, 2 mm diametro, glaber, margine crenatus; ovarium ovoideum, 1.5 mm longum et 1.3 mm diametro, sparse pilosum, 4-loculare (raro 5-loculare) ovulis in loculis 2; stylus brevis; stigma capitatum, 4-lobulatum (raro 5-lobulatum). Fructus deest.

Large tree 25 m tall and 50 cm in trunk diameter, in wet tropical forest. Wood used for lumber. "Quemapecho."

Esmeraldas: San Lorenzo, altitude about 10 m, April 20, 1943, *Little 6292* (Forest Service no. 96876; U. S. Nat. Herb. no. 1877653, type).

Six species of *Tetragastris* Gaertn. are recognized in the recent monograph by Swart (Rec. Trav. Bot. Neerland. **39**: 403–419, illus. 1942), and another was published in 1939. This generic name is retained here over the technically valid, older generic name *Hedwigia* Sw. (1788), which is not in use. *Hedwigia* [Ehrh. 1781] Beauv. (1805) should be made a *nomen conservandum* for a monotypic genus of mosses (Little, Bryologist **46**: 114–115. 1943). The genus is distributed from Brazil and British Guiana to the West Indies and Central America and now

FIG. 11.—*Symplocos ecuadorensis*, $\frac{1}{3}\times$; flowers, $1\times$; fruit, $1\times$. FIG. 12.—*Humiria procera*, including fruit and two old fruits showing bony endocarp, all $\frac{1}{3}\times$. FIG. 13.—*Neosprucea pedicellata*, $\frac{1}{3}\times$; flower $\frac{2}{3}\times$. FIG. 14.—*Erythrochiton carinatus*, $\frac{1}{3}\times$; carpels of fruit, $1\times$.

is reported for the first time from Ecuador and the Pacific slope of South America.

Tetragastris varians is easily distinguished by the broadly elliptic leaflets, which vary in number. Leaves at the ends of twigs have only 3 leaflets or 1, but apparently some leaves have more leaflets. Other species of the genus have narrower leaflets, 5 (rarely 3) to 11 in number. In the new species the calyx is glabrous, the corolla is minutely strigillose outside and glabrous inside, and the ovary is sparsely pilose. Specimens of the type collection in the U. S. National Herbarium and Forest Service Herbarium are terminal portions of twigs with both trifoliolate and unifoliolate leaves. However, the type bears, at a distance of 30 cm from the apex of the twig, the base of a much longer pinnate leaf with petiole 21 cm long and with a single leaflet attached.

Guarea polymera Little, sp. nov.
Fig. 4

Sect. *Euguarea* C. DC. Arbor 12 m alta, myrmecophila, trunco 15 cm diametro. Ramuli minute et dense brunneo-glanduloso-tomentulosi. Folia pinnata; petioli 6–7 cm longi, supra canaliculati; rhaches ca. 26 cm longi; foliolae 6- vel 7-jugae, breviter (4–5 mm) petiolulatae; laminae oblongo-lanceolatae, base acutae, apice acuminatae, membranaceae, 20–23 cm longae, 6–7 cm latae, supra glabrae, subtus inconspicue et minute cinereo-puberulae, nervis lateralibus utrinque 12–15, ascendentibus et margine curvatis, his cum costa supra fere planibus, subtus prominentibus. Paniculae axillares 6–12 cm longae, 3–6 cm latae, ramulis minute glanduloso-tomentulosis, bracteae triangulares, acutae, 2–3 mm longae; pedicelli clavellati 5–15 cm longi. Flores albidi, fragrantes, (5) 6- vel 7-meri, calyx late cupulatus, 3 mm longus, 7 mm latus, leviter 10–16-lobatus, lobulis 0.5 mm longis, mox 3–4-fissus fere ad basin, externe brunneo-tomentulosis, intus glaber. Petala 5–7, valvata, lanceolata, acuta, leviter involuta, 10 mm longa, 3 mm lata, externe dense albido-sericeo-tomentulosa, intus glabra; tubus stamineus cylindricus, margine crenulatus, 7 mm longus, 4 mm diametro, glaber; antherae 10–14, inclusae, sub margine sessiles, 1.5 mm longae; gynophorum 1 mm altum, glabrum, apice annulum glandulosum gerens, 4 mm diametro; ovarium ovoideum, sulcatum, dense sericeo-tomentulosum, 3 mm longum, 2.5 mm diametro, 6–8-loculare, loculis 2-ovulatis, ovulis superpositis; stylus crassus, strigillosus, 3 mm longus, 1 mm diametro; stigma crassum discoideum, glabrum, 2 mm diametro. Capsula fere matura globosa, rugulosa, brunnea, 11 mm diametro, 6–8-loculare; semina in loculo 2 superposita, atra, ca. 3 mm longa.

Tree 12 m tall and 15 cm in diameter, said to become larger. Twigs hollow and inhabited by ants. Wet tropical forest. "Pialde macho."

Esmeraldas: Playa de Oro, altitude 65 m, April 30, 1943, *Little 6404* (Forest Service no. 98254; U. S. Nat. Herb. no. 1877588, TYPE; with wood sample).

This specimen is readily associated with the group of a few species in the large genus *Guarea* Allem. ex. L. and Sect. *Euguarea* C. DC. having ovaries and capsules with more than 5 cells (6 to 12). The flowers are 6- or 7-merous, rarely 5-merous, and the ovaries are 6–8-celled. Petals are 5 to 7, instead of the usual number in this genus, 4 or 5. The wood sample was identified by S. J. Record as *Guarea*. Other species with approximately the same number of carpels are *G. purusana* C. DC., of Amazonian Brazil, with 6–9-celled ovary but much larger fruit and dense brownish pubescence, and *G. grandifolia* DC., of Guiana, 7-celled but otherwise 4-merous. This Ecuadoran collection contains also specimens of *G. syringoides* C. H. Wright (?) and *G. trichilioides* L.

Perhaps *Guarea* Allem. ex L. (Mant. Pl. **2**: 150. 1771) should be made a *nomen conservandum* over *Elutheria* P. Br. (Civ. Nat. Hist. Jamaica 369. 1756). The latter was referred to *Guarea* by Fawcett and Rendle (Fl. Jam. **4**: 215. 1920) and cited by Harms (in Engler and Prantl, Natürl. Pflanzenfam. ed. 2, **19bI**: 129. 1940). Rendle (Journ. Bot. **50**: 129. 1912) contended that it was unnecessary to conserve names against earlier names by Patrick Browne observing that Browne published descriptions of species only, not genera. Whether Browne's descriptions in monotypic genera, such as *Elutheria*, would be valid as combined generic and specific descriptions (art. 43) is uncertain because binomial nomenclature was not adopted. Nevertheless, several generic names of Browne having priority have formally been made *nomina rejicienda*.

Trichilia floribunda Little, sp. nov.
Fig. 10

Sect. *Moschoxylum* (A. Juss.) C. DC. Arbor 10–20 m alta vel major, trunco 20 cm diametro. Ramuli minute strigillosi. Folia alterna, magna, imparipinnata; petioli 8–11 cm longi; rhaches 30–35 cm longae; foliolae 11–14, alternae; petioluli 5–12 mm longi; petioli, rhaches, et petioluli minute strigillosi; laminae foliolarum oblanceolatae, (11) 25–33 cm longae et (5) 7–10 cm latae, infimae minores, basi acutae, apice acutae, integrae, subcoriaceae, supra glabrescentes, subtus minute et sparse puberulentae vel glabrescentes, nervis lateralibus utrinque (9) 20–25, ascendentibus, marginem versus curvatis, his cum costa supra fere planibus vel leviter impressis, subtus prominentibus. Paniculae axillares, corymbiformes, multiflorae, 20–30 cm longae, fere 20 cm latae, ramulis strigillosis; pedicelli tenues, 1–2 mm longi; flores flavo-albidi, fragrantes; alabastrum oblongo-ovoideum, 6 mm. longum et 2–2.5 mm latum; calyx patelliformis, brevissimus, subinteger vel leviter 4- vel 5-lobulatus, 0.5 mm longus et 2.5 mm latus, externe strigillosus, intus glaber; corolla in alabastro 6 mm longa et 2–2.5 mm diametro, externe dense cinereostrigillosa, intus glabra; tubus cylindricus, 4-lobatus (raro 3-lobatus) fere ad medium, lobis lanceolatis, obtusis, cucullatis, valvatis, leviter involutis; tubus stamineus urceolatus, 4 mm. longus, apice 6–8 denticulatus (denticulis 1 mm longis), externe glabrescens vel parce appresso-pilosus, intus hirtellus; antherae 6–8, vulgo 7, inter denticulos insertae, exsertae, 1 mm longae; ovarium ovoideum, cum gynophoro 1.5 mm longum et 1 mm latum, dense strigillosum, 2- vel 3-loculare, loculis 2-ovulatis; stylus tenuis, inferne strigillosus, 1.5 mm longus; stigma clavatum. Fructus deest.

Tree 10–20 m tall and 20 cm in diameter, reported to become a large tree of forest canopy. Wood said to be used for axe handles. Possibly of ornamental value because of the abundant small, yellowish-white, fragrant flowers. Wet tropical forest of northwestern Esmeraldas. "Pialde."

ESMERALDAS: San Lorenzo, altitude 10 m, April 21, 1943, *Little 6323* (Forest Service no. 96852; U. S. Nat. Herb. no. 1877646, TYPE); Borbón, altitude 15 m, April 26, 1943, *Little 6372* (Forest Service no. 98283; with wood sample).

The very numerous flowers in this species of *Trichilia* P. Br. have a saucerlike calyx very slightly 4- or 5-lobed, and the 4-lobed corolla united more than half its length. This species has relatively large leaves and leaflets for the genus. S. J. Record named the wood sample as *Trichilia.* Also represented in this collection are *T. hirta* L and *T. macrophylla* Benth.

Belotia australis Little, sp. nov.
Fig. 1

Arbor 18 m alta vel major; trunco 35 cm. diametro. Cortex glaber, albidus. Ramuli et petioli minute dense stellato-puberuli, grisei. Petioli 8–15 mm longi. Laminae ellipticae vel lanceolatae, 9–14 cm longae, 3–6 cm latae, basi obtusae vel acutae, apice acuminatae, acumine 1–1.5 cm longo, glanduloso-serrulatae, 3-nervatae, chartaceae, discolores, supra virides, minute sparse stellato-puberulae, subtus griseae, minute dense stellato-puberulae, pilis paucis stellatis majoribus praeditae. Inflorescentia cymosa axillaris, 3–6 cm longa, ca. 10-flora; pedicelli 3–6 mm longi; bracteae lanceolatae, 2–4 mm longae, interdum 2- vel 3-dentatae; pedunculus et pedicelli bracteaeque minute dense stellato-puberulae, griseae; alabastra ca. 8 mm longa; flores 10–11 mm longi; sepala 5, rubella, lanceolata, 9–11 mm longa, 2.5 mm lata, margine involuta, apice obtusa, cucullata, 5-nervata, externe minute dense stellato-puberula, intus fere glabra, pilis paucis stellatis praedita; petala 5, ligulata, 8–9 mm longa, 1.5 mm lata, apice 2–4-dentata, 5-nervata, externe sparse pubescentia, intus basi et circum nectarium stellato-pilosa, ceterum glabra; androgynophorum 1 mm altum, apice discum dense stellato-pilosum 3 mm diametro ferens; stamina 15, 2–3 mm longa; filamenta deorsum stellato-pilosa; antherae suboribculares, 0.3 mm longae; ovarium ovoideum, 3 mm longum, 2.5 mm diametro, dense pilosum, 2-loculare, ovulis paucis; stylus 3–4 mm longus, basi stellato-pilosus; stigma 4-lobatum, lobis laciniatis, 0.5 mm longis. Capsula bilocularis, valde obcompressa, loculicida, brunnea, 15 mm longa, 20 mm lata, 4 mm crassa, basi rotundata, apice truncata, sparse puberula, pilis minutis stellatis et pilis stellatis multo longioribus interspersis, stylo persistente cuspidato 3 mm. longo coronata. Semina desunt.

Tree 18 m tall or larger, and 35 cm in diame-

ter. Bark smooth, whitish. The light-weight wood is sometimes mixed with that of balsa (*Ochroma lagopus* Sw.) and substituted for the latter. Scattered in cutover wet tropical forest and fields at San Lorenzo but not common. "Chillarde." Also improperly called "balsa."

ESMERALDAS: San Lorenzo, altitude about 10 m, April 19, 1943, *Little 6273* (Forest Service no. 96826; U. S. Nat. Herb. no. 1858843, TYPE; with wood sample).

In the genus *Belotia* A. Rich., T. A. Sprague (Kew Bull. 1921: 270–278. 1921) distinguished 11 species, including 6 new, distributed from southern Mexico through Central America to Panama and in Cuba and Santa Lucia in the West Indies. A. A. Bullock (Kew Bull. 1939: 517–521. 1939) later examined additional material and reduced the number of species to 9. Sprague predicted that this genus might be found later in the Pacific coast forests of Colombia, and this collection represents a further southward extension of *Belotia* to Ecuador.

Belotia australis is related to *B. panamensis* Pittier (*B. macrantha* Sprague) of Panama. Pubescence in the former is finer, more minute, and gray, while the latter has the twigs and branches of inflorescence coarsely ferrugineous tomentose. The leaves of *B. panamensis* usually are larger, rounded or obtuse at base, and with teeth more prominent. The under surface of the leaves in *B. australis* has finer pubescence with the larger hairs of the upper tier scattered and fewer. The flowers of *B. panamensis* are slightly larger. Capsules in both species are similar in size and shape, but those of *B. panamensis* are much more densely stellate pubescent and have shorter styles less than 3 mm long.

Sprague noted that the common name "balsa," which is applied to *B. australis*, is used also in British Honduras for *B. campbellii* Sprague.

Matisia alata Little, sp nov.

Fig. 16

Arbor 20 m. alta, trunco 20–30 cm diametro. Ramuli et petioli minute stellato-tomentosi, pilis flavis, radiis numerosis, brevissimis, glandulosis, demum glabrescentes. Folia magna petiolata, petiolis 2–5 cm longis; laminae oblongo-obovatae, 15–38 cm longae, 8–18 cm latae, basi subrotundatae vel leviter cordatae, apice acutae, margine integrae vel obscure undulatae, penninervis, nervis lateralibus 9–12 utrinque latere, prope marginem arcuatis et anastomosantibus, subtus elevatis, venulis prominente reticulatis, supra glabratae, subtus sparse et minute stellato-puberulae. Flores solitarii, oppositifolii, 2 vel 3 apice ramulorum, magni, 7 cm longi; pedicellus crassus, curvatus, fulvus, 4–7 cm longus, 3 mm diametro; calyx anguste campanulatus, 45 mm longus, 22 mm diametro cum alis, basi attenuatus, crassus, plus minusve succulentus, ochraceus, dense et minute stellato-tomentosus, pilis glandulosis, intus dense sericeus, lobis 5 brevibus, acutis, 3–5 mm longis, alis 10, longis, angustis, usque ad 6 mm latis; petala 5, ochracea, 70 mm longa, basi connata tubo 2 mm, limbo spatulato vel obovato, obtuso, ca. 32 mm longo et 15–18 mm lato, externe dense stellato-tomentoso, intus glabro; columna staminea longe exserta, leviter curvata, 5 cm longa, 5-lobata, lobulis leviter pubescentibus, 10–16 mm longis, antherarum loculis 4–6 linearibus; ovarium 5-lobatum, 5-loculare, 3 mm longum, stellato-tomentosum; stylus 60 mm longus, 10 mm exsertus, curvatus, stellato-tomentosus; stigma capitatum, 2 mm longum. Fructus globosus, succulentus, ochraceus, magnus, 8–10 cm diametro, calyce accrescente 6–7 cm longo, cum alis 4–10 mm latis, suffultus.

Tree 20 m tall and 20–30 cm in trunk diameter. It is said that the large, fleshy fruits are edible. Observed also at San Lorenzo, Esmeraldas. Wet tropical forest of Esmeraldas and Pichincha, northwestern Ecuador. "Sapote," "sapotillo."

ESMERALDAS: Quinindé, altitude 65 m, April 12, 1943, *Little 6244* (Forest Service no. 96751; U. S. Nat. Herb. no. 1858828, TYPE). PINCHINCHA: between Santo Domingo de los Colorados and Quinindé, April 7, 1943, *Little 6197* (Forest Service no. 96867); April 8, 1943, *Little 6200* (Forest Service no. 96785; in fruit).

More than 20 species of the genus *Matisia* H. B. K. have been described, a third of these in 1945–1946. This genus of small to medium-sized trees ranges from Brazil to Colombia and Ecuador and north to Panama and Costa Rica. Some of the species apparently are of local range. In this Ecuadorian collection are *M. cordata* Humb. & Bonpl., a cultivated species, *M. coloradorum* R. Benoist, an Ecuadorian species found again at the type locality, and two species proposed here as new.

FIG. 15.—*Clusia polystigma*, including bud and immature fruit, all $\frac{1}{3}\times$. FIG. 16.—*Matisia alata*, $\frac{1}{6}\times$; flower, $\frac{1}{3}\times$. FIG. 17.—*Clusia plurivalvis*, including separate staminate flowers and fruits, all $\frac{1}{3}\times$. FIG. 18.—*Matisia grandifolia*, $\frac{1}{6}\times$; flower, about $1\times$.

Matisia alata, one of the few species with pinnately veined leaves, is distinguished from other species of the genus by the prominent wings on the calyx, to which the specific name refers, and by the large flowers, which are orange or brownish in color. The 10 conspicuous wings of the calyx tube are longitudinal, narrow, slightly curled projecting ridges, starting at the base of the calyx and reaching a maximum width of 6 mm. near their rounded ends of the apex of the calyx. The 5 wings opposite the calyx lobes are larger, while the alternate wings are smaller and shorter or may be almost absent.

Matisia grandifolia Little, sp. nov.
Fig. 18

Arbor parva, 5 m alta, trunco 5 cm diametro. Ramuli et petioli dense et minute stellato-tomentosi, pilis multiradiatis, glandulosis. Folia magna, petiolata, petiolis 1–1.5 cm longis, 4 mm diametro; laminae late ellipticae, 50–60 cm longae, ca. 28 cm latae, basi rotundatae, apice acuminatae, margine integrae vel obscure undulatae, penninervis, nervis lateralibus 12–14 utrinque latere, prope marginem arcuatis et anastamosantibus, subtus elevatis, venulis prominente reticulatis, supra glabrae, subtus minute stellato-puberulae. Flores pauci, solitarii, oppositifolii, 3–3.5 cm longi; pedicellus brevis, leviter curvatus, 5–7 mm longus; bracteis 3, basi floris, subulatis, 3–6 mm longis; calyx anguste campanulatus, fulvus, 22–25 mm longus, 8 mm diametro, uno latere 10–12 mm fissus, lobis plerumque cohaerentibus, saepe 2–4, sinubus 2–7 mm longis, alis 10 longis, angustis, 1 mm latis, dense et minute stellato-tomentosus, pilis glandulosis, intus dense sericeus, petala 5, in sicco rubida, anguste oblanceolata, apice obtusa, 30–34 mm longa, 4–5 mm lata, externe apice appresso-stellato-tomentosa; columna staminea 17–20 mm longa, apice leviter pubescens, 4- vel 5-lobata, lobulis 3–9 mm longis, antherarum loculis ellipticis usque ad 8; ovarium conicum, 5-loculare, 3–4 mm longum, stellato-tomentosum; stylus 24 mm longus, 3 mm exsertus, stellato-tomentosus; stigma 5-lobatum, lobulis obtusis, fere 2 mm longis. Fructus deest.

Small tree 5 m tall and 5 cm in diameter, said to become larger. One tree seen in cacao plantation, wet tropical forest area. "Penimón."

Pichincha: Santo Domingo de los Colorados, altitude 560 m, April 7, 1943, *Little 6146* (Forest Service no. 96782; U. S. Nat. Herb. no. 1858834, TYPE).

This species is characterized by unusually large, pinnately veined leaves, by the short pedicels, and by the calyx split on one side, with 10 narrow wings or ridges.

Clusia plurivalvis Little, sp. nov.
Fig. 17

Arbor dioica, recta, extensa, 15 m alta, trunco 30 cm diametro. Cortex fuscus, leviter asper, fissus, latice alba. Ramuli crassi, teretes. Folia petiolata; petioli 1.5–4 cm longi, 4–7 mm lati, leviter alati; laminae ovales vel obovatae, (8) 12–24 cm longae, (5) 8–14 cm latae, basi obtusae vel acutae, apice rotundatae, valde coriaceae, nervis lateralibus numerosis, parallelis, sub angulo ca. 60–70° adscendentibus. Inflorescentia terminalis, capitata, pauciflora pedunculo crasso, 2.5–4 cm longo, 6 mm diametro, floribus sessilibus. Flores masculi magni, 5 cm diametro; bracteae calycinae rotundae, 4–9 mm longae, 8–13 mm latae, obtusae, carinatae; sepala 4–6, biseriata, late rotundata, obtusa, concava, coriacea, 2 inferiora minora 6–10 mm longa et 15 mm lata, superiora 10–15 mm longa et 12–20 mm lata; petala 5, obovata, 28–32 mm longa, 20–25 mm lata, obtusa, in vivo alba, basi incarnata vel ochracea; stamina in disco convexo 5–6 mm alto et 10–13 mm diametro inserta, numerosissima, spissa, fere sessilia, antheris 1.5 mm longis, longitudinaliter dehiscentibus; staminodia in globo resinoso 5 mm diametro apice disci aggregata. Flores feminei desunt; sepala in fructu persistentia, similia sepalis florium masculorum; staminodia nulla. Capsula succulenta depresso-globosa, 17 mm alta et 21 mm diametro, 13–16-locularis et 13–16-valvatis; stigmata 13–16, peltata, radiata, sessilia, triangularia, plana, 8 mm longa et 2–3 mm lata, atra, in disco 17 mm diametro; semina in loculis 2.

Large, erect, widely spreading tree 15 m tall and 30 cm in trunk diameter. Bark dark brown, slightly rough, with white latex. Common and with another, probably undescribed species of *Clusia* (*Little 6769*) a dominant tree species of the dry mountain forest in ravines at Huigra. Common name "lamai," according to Rose.

Chimborazo: Huigra, altitude 1300 m, July 17, 1943, *Little 6768A* (Forest Service no.

98525; U. S. Nat. Herb. no. 1857089, TYPE; with fruits). *Little 6768* (Forest Service no. 95852; with staminate flowers). *Little 6768B* (Forest Service no. 98526; with staminate flowers). Huigra, Aug. 19, 1918, *J. N. Rose and George Rose 2223* (U. S. Nat. Herb. no. 1021907; with fruits and staminate flowers but also containing larger, detached, sectioned fruits of a different species).

Rose and Rose 2223 bears the note, " 'Not at Kew' N. L. B[ritton]. Sept. 1920." *Clusia plurivalvis* is not readily placed in the proper section in the latest summary of *Clusia* L. by Engler (Natürl. Pflanzenfam. ed. 2, **42:** 199–204. 1925). It seems to be in subgenus *Thysanoclusia* Vesque and related to section *Euclusia* Planch. & Triana, which differs in having the connectives elongate and pointed. In this species the numerous stamens are crowded and almost sessile in a convex disc, which bears a central resinous mass of staminodia. The number of carpels in the ovary in this species, 13–16, is very high. Of the species in which the number of carpels is known, only a few, such as *C. flava* Jacq. with 12–14 carpels, *C. cuneata* Benth. with 16, and the new species described below have more than 12 carpels.

FIG. 19.—*Aspidosperma elatum*, $\frac{1}{2}\times$; fruit, $\frac{1}{2}\times$.

Clusia polystigma Little, sp. nov.
Fig. 15

Epiphyta magna, scandens, arborea, dioica, 10 m alta, trunco 10 cm diametro. Ramuli crassi, teretes. Folia subsessilia, obovata, 15–20 cm longa, 8–11 cm lata, basi angustata et subpetioliformes, apice obtusae, valde coriaceae, nervis lateralibus numerosis, parallelis, sub angulo ca. 50° adscendentibus. Flores masculi desunt. Inflorescentia feminea terminalis, racemosa, pauciflora, rhache 6 cm longa, bracteata, bracteis oppositis, late ovatis, 5–8 mm longis et 6–10 mm latis; pedicelli 3–6 mm longi; bracteae calycinae 2 late rotundatae, 3 mm longae et 5–6 mm latae, obtusae, crassae; sepala 4–6, biseriata, late rotundata, obtusa, coriacea, minora 2 inferiora, 7–11 mm longa et 9–12 mm lata, 2–4 superiora 15–16 mm longa et 12–18 mm lata; petala 6 vel 7, obovata, 32–34 mm longa et 22–24 mm lata, obtusa, in vivo albida, leviter incarnato-tincta; cupula staminodialis 3–4 mm longa, 12 mm diametro, apice leviter lobata; ovarium cylindricum, 4 mm longum, 6 mm diametro, sulcis longitudinalibus et loculis 16–19, loculis multiovulatis; stigmata 16–19, radiata, sessilia, anguste triangularia, 5–6 mm longa et 1.5 mm lata, atra, connata in annulo 4–5 mm longo et 8–9 mm diametro. Capsula succulenta immatura subglobosa, 18 mm longa et 16 mm diametro, sulcata, stigmatibus sessilibus coronata.

Large woody vine 10 m tall and 10 cm in trunk diameter, epiphytic on a tree of *Ficus* sp. nov. (*Little 6356*) left in a clearing, wet tropical forest. "Matapalo."

ESMERALDAS: San Lorenzo, altitude about 10 m, April 23, 1943, *Little 6355* (Forest Service no. 98245; U. S. Nat. Herb. no. 1857080, TYPE).

In the absence of staminate flowers, this species of *Clusia* L. cannot be definitely placed as to section. When more material is available, this species perhaps may be included in subgenus *Thysanoclusia* Vesque, section *Euclusia* Planch. & Triana, according to the summary by A. Engler (Natürl. Pflanzenfam. ed. 2, **21**: 199–204. 1925). The large, 6- or 7-petaled flowers suggest affinities with this section. This species is readily distinguished by the very high number of carpels, 16–19, apparently more than have been recorded previously in this genus.

Neosprucea pedicellata Little, sp. nov.
Fig. 13

Arbor parva, 10 m alta, trunco 20 cm diametro, ramulis teretibus griseis, minute appresso-pubescentibus. Folia petiolata, petiolis appresso pubescentibus, 12–16 mm longis; laminae ellipticae, 10–20 cm longae, 6–10 cm latae, membranaceae, basi subrotundatae, apice attenuatae, margine remote obtuseque glanduloso-serratae, e basi distincte triplinerviae, glabrae nervis subtus minute paullo appresso-pubescentibus exceptis. Racemus lateralis laxus divergens, pauciflorus (2 vel 3), 5–6 cm longus; rachis et pedicelli subangulati, minute denseque tomentosi; pedicelli 25–30 mm longi; flores magni, albidi, sepala et petala similia, valvata, persistentia, utrinque breviter denseque appresso-tomentosa; sepala 4, basi leviter connata, ovata, 16–17 mm longa, 5–7 mm lata, acuminata, 5–8-nervata; petala 4, ovata, acuta, carinata, 15–17 mm longa; stamina numerosa; filamenta filiformia, 2 mm longa; antherae linearae, hirsutae, 5 mm longae; receptaculum dense hirtum; ovarium globosum, fere glabrum, 5 mm diametro, semi-5–7-loculare, placentis parietalibus prominentibus; stylus crasse filiformis, 9 mm longus; stigmate truncato. Fructus deest.

Small tree about 10 m. tall and 20 cm. in diameter, wet tropical forest.

PICHINCHA: Santo Domingo de los Colorados altitude about 560 m, April 2, 1943, *Little 6152* (Forest Service no. 96909; U. S. Nat. Herb. no. 1858861, TYPE).

Neosprucea Sleumer (Notizbl. Berl. **14**: 47. 1938), a monotypic genus of the Flacourtiaceae, was based upon *N. grandiflora* (Spruce) Sleumer (Notizbl. Berl. **44**: 47. 1938), originally described as *Banara grandiflora* Spruce (Journ. Linn. Soc. Bot. **5**. Suppl. **2**: 93. 1861). The type was collected at Tarapoto, Peru, by Spruce, and the species now is known from the Atlantic slope in Brazil, Colombia, and Peru. The second species, *N. pedicellata*, represents an extension of range of the genus to Ecuador and possibly the first record on the Pacific slope.

N. pedicellata is a distinct species readily separated from the type species by the following characters: leaves membranaceous (instead of chartaceous); leaves mostly larger, broader, and rounded at base; petioles slightly longer;

greatly elongated pedicels 25–30 mm long; and larger flowers. Though *N. grandiflora* was described by Sleumer with a spikelike raceme and pedicels only 2 mm. long, Mutis' specimens from Colombia have pedicels 10 to 20 mm. long.

Symplocos ecuadorensis Little, sp. nov.
Fig. 11

Subgenus *Eusymplocos* Brand, sect. *Symplocastrum* Brand, subsect. *Ciponimastrum* Brand. Arbor 15 m alta, trunco 20 cm diametro. Ramuli leviter hirsuti. Folia petiolata, petiolis hirsutis, 5–8 mm longis; laminae oblanceolatae, 5–10 cm longae, 2.5–4 cm latae, basi cuneatae, apice abrupte acuminatae, remote crenulatae, subcoriaceae, lucidae, supra glabrae, subtus parce hirsutulae, costa et venis primariis subtus prominentibus. Paniculae axillares, 1–2 cm. longae, rachibus hirsutis, bracteis ovatis, hirsutis, ciliatis, 1 mm longis; flores 7–8 mm longi, subsessiles; calyx 2–2.5 mm longus, hypanthio campanulato ca. 1 mm longo, glabro, lobis 5, late ovatis, ciliatis, 1–1.5 mm. longis; corolla alba, 6–7 mm longa, tubo ca. 3 mm longo, lobis 5, ellipticis, obtusis, apice ciliolatis, 3–4 mm longis et 2 mm latis; tubus stamineus tubo corollae adnatus, 1 mm longus; stamina 28–32 triserialia; filamenta complanata, 0.2–2.5 mm longa; ovarium fere omnino inferum, 1.5 cm. altum, apice pilosum, 3- vel 4-lobulatum. Fructus baccatus, cylindricus, lobis calycinis et basi styli coronatus, 10 mm. longus, 5 mm diametro, 3- vel 4-locularis.

Tree 15 m tall and 20 cm in diameter. Two trees were seen in a pasture, cleared wet tropical forest.

ESMERALDAS: San Lorenzo, altitude about 10 m, April 22, 1943, *Little 6349* (Forest Service no. 98370; U. S. Nat. Herb. no. 1858685, TYPE).

Though the genus *Symplocos* Jacq. is widely distributed with about 300 species in tropical and subtropical America, Asia, and Australia, most species have restricted ranges. This material from the poorly explored Ecuadorian province of Esmeraldas could not be assigned to any of the species from northwestern South America.

Aspidosperma elatum Little, sp. nov.
Fig. 19

Arbor magna, 35 m alta; trunco 1 m diametro, profunde sulcato et angulato. Cortex fere laevis, leviter fissus, albido-griseus. Ramuli subteretes, puberuli. Folia alterna, non congesta, internodiis 4–7 cm longis, petiolata, petiolis fusco-puberulis, 1 cm longis; laminae magnae, oblongo-oblanceolatae, chartaceae, 22–26 cm longae, 7–9 cm latae, basi subrotundatae, apice acutae vel obtusae, fere glabrae, supra virides, subtus glaucescentes, costa leviter puberula, supra canaliculata, subtus elevata, nervis lateralibus utrinque 13–16, fere rectis, prope marginem leviter arcuatis, subtus elevatis, secundariis inconspicuis. Inflorescentiae desunt. Mericarpia magna, compressa, suborbicularia, 10–12 cm longa, 9–10 cm lata, 2 cm crassa, externe dense fusco-tomentosa, pericarpio lignoso, 5–8 mm crasso; semina plano-compressa, suborbicularia, 9 cm longa, 7 cm lata, alis latis, papyraceis.

Large tree of forest canopy, to 35 m tall and 1 m in trunk diameter. Easily recognized in the field by the odd, fluted trunk with deep, branching, vertical grooves. Bark smoothish, slightly cracked, whitish-gray. Wet tropical forest at Pichilingue. "Naranjo de monte."

LOS RÍOS: Pichilingue, altitude about 45 m, May 25, 1943. *Little 6517* (Forest Service no. 98223; U. S. Nat. Herb., TYPE).

The genus *Aspidosperma* Mart. & Zucc. is widely distributed in tropical America from Mexico and the West Indies to Brazil and Argentina, centering in Brazil and represented in northwestern South America by only a few species. Four species were recorded from Colombia by Standley (Trop. Woods **36:** 13–20. 1933). The herbarium material of *Aspidosperma elatum*, which consists of foliage and detached fruits, seems sufficiently distinctive, as the leaves and fruits are larger than in most species. Apparently this is the second species of *Aspidosperma* recorded from Ecuador.

HERPETOLOGY.—*A collection of salamanders from Mount Rogers, Virginia.*[1]

RICHARD L. HOFFMAN and HUBERT I. KLEINPETER. (Communicated by HERBERT FRIEDMANN.)

Although White Top Mountain, Va., is well known to students of salamander distribution, and is subjected to periodic depredation by different collectors; its adjacent neighbor to the northeast, Mount Rogers, has apparently escaped the attention of most herpetologists. The absence of any particular road to the summit of Mount Rogers may be partly responsible for this neglect.

When, in the summer of 1947, we had the opportunity to be in southwestern Virginia, we avoided White Top believing that we could make no particular contribution by further depleting its already well-known herpetological fauna. Instead a period of three days was spent on Mount Rogers. Our station was located on the eastern slope, in Grayson County, at an elevation of about 4,500 feet, from which one all-day journey was made to the top, as well as many short trips in the general region about the camp.

The lower slopes of the mountain are thickly forested with a mesophytic flora which might be characterized as a maple-hemlock-dogwood association, with comparatively little undergrowth of herbaceous plants. Although fir and spruce trees are widely scattered, the extensive stands are restricted to the uppermost 500 or 600 feet of the knob. Here red spruce, *Picea rubra* (DuRoi) Dietr., and southern fir, *Abies fraseri* (Pursh) Poir., seem to comprise the entire evergreen forest, the latter being by far the more abundant. The ground is completely covered by mosses and thick carpets of the wood sorrel, *Oxalis acetosella* L. A striking feature of the evergreen stands is the large number of logs and stumps, all in approximately the same stage of decomposition. The more level parts of the top are covered by heavy growths of various ferns.

From a physiographic standpoint, the Balsam Mountains (of which White Top and Mount Rogers form the bulk) are characteristic of the Southern Section of the Blue Ridge Province. White Top has previously been designated part of the Iron Mountains, but the recent Mount Rogers Quadrangle (*q.v.*) of the U. S. Geological Survey ranks the Iron and Balsam Mountains as separate units.

Although a rather large number of salamanders was encountered, they represented but a few species. The contrast between the salamander fauna of White Top and Mount Rogers is interesting in that the following species reported from the former were not found by us on Mount Rogers: *Triturus v. viridescens*, *Desmognathus monticola*, *Plethodon c. cinereus*, *P. g. glutinosus*, *P. yonahlossee*, and *Pseudotriton ruber nitidus*. It is difficult to account for the apparent absence of several of these species, whereas at least one other form which is scarce on White Top (*Plethodon welleri*), is extremely common on Rogers. In the case of *P. yonahlossee*, it is not inconceivable that we collected above its maximum elevation preferences. The lower slopes seemed very favorable for *P. glutinosus*, but the only *Plethodon* found there was *metcalfi*, which was present in considerable numbers.

In addition to the salamanders which (with the exception of a small series of a strange *Desmognathus* reserved by the junior author for further examination) have been donated to the United States National Museum, the following amphibians and reptiles were found on Mount Rogers: *Bufo terrestris americanus*, *Lampropeltis t. triangulum*, and *Thamnophis s. sirtalis*. One specimen of the last named was seen sunning itself on a rock at approximately 5,500 feet; the others were all seen near our station at 4,500 feet.

We take pleasure in indicating our gratitude to Drs. Horton H. Hobbs, Jr., and Arnold B. Grobman for help in preparation of this paper, and to Dr. Doris M. Cochran for courtesies attendant upon our visits to the National Museum.

[1] Received October 20, 1947.

LIST OF SPECIES

Desmognathus fuscus fuscus (Rafinesque)

Six specimens, which were not presented to the Museum, were collected in a large seepage area located in a cleared saddle on the northeast side of Mount Rogers. This species was not represented farther down in the stream emanating from the spring.

Desmognathus ochrophaeus carolinensis Dunn

Sixteen individuals, U.S.N.M. nos. 124455–70, were collected at elevations from 4,500 to 5,700 feet. The species seemed to be equally common in evergreen and deciduous forests.

Desmognathus quadramaculatus quadramaculatus (Holbrook)

Nine specimens, mostly large adults, U.S.N.M. nos. 124471–79. On July 2 we collected in a small but cold and swift stream on the eastern slope of the mountain at an elevation of about 4,300 feet. This species was especially common; most of the specimens found being under submerged rocks in rapids. The largest specimen included in our series measures 78 mm from snout to vent, a size not approached by specimens from farther north in Virginia.

Desmognathus wrighti King

Two adults, U.S.N.M. nos. 124480 and 124634, were collected at an elevation of approximately 5,600 feet. They were found in rotting logs in company with *Plethodon welleri*. Mount Rogers is the northernmost locality at which this diminutive salamander has been found.

Plethodon metcalfi Brimley

Eight specimens, U.S.N.M. nos. 124412–18, 124631. This species shares with *D. o. carolinensis* the distinction of being one of the two most abundant salamanders on Mount Rogers, and the size of our series is in no way indicative of the abundance of the animal. In the evergreen forests, *metcalfi* occurred all the way to the very summit of the mountain, although less common on the top; in and under logs but not in stumps.

Plethodon welleri Walker

Eleven specimens, U.S.N.M. nos. 124442–49, 124632–33. The size of the series serves to indicate the relative abundance of this heretofore supposedly rare species. Far more were collected than were retained. It was not until we were several hundred yards within the evergreen forest that we found the first *welleri*, but thereafter almost every log or stump examined contained one and occasionally two specimens. Most frequently, *welleri* was found in decaying, moss-covered stumps, usually in the upper portion. Individuals found in logs were usually lying with the body in a "U"—the end of the tail near the head. Many of them remained still and were easily caught.

One log, nearly at the top, was found to contain two females with their eggs. This log, seemingly identical with many others investigated, was supported about 18 inches above the ground. The females were discovered in small crevices in the damp wood, about 6 inches apart, an inch under the surface of a layer of moss. Both were curled around the eggs, and showed some reluctance to leave them. In fact, one, on being dislodged, moved back after a short time. The larger clutch contained nine eggs, which were slightly pear-shaped and averaged 4.2 (3.6–5.0) mm in the largest diameter. We could detect no particular pedicles, and the eggs clung together by the adhesive nature of the outer envelopes. The smaller clutch included seven eggs, which are arranged in a ring of five with one above and below at the center. In color, the eggs were a light creamy yellow, and no trace of embryos could be discerned within. The mothers differed in size in accordance with the number of eggs, the larger measuring 47 mm snout to vent (87.5 mm total length) and the smaller 43.5 mm snout to vent (79.1 mm total length). It is interesting that of the many *welleri* seen, the only two with egg masses were in the same log. We wonder if it was due to coincidence or to a tendency of the females to congregate at a sort of *Wochenstube* where conditions for hatching and growth (not apparent to humans) are optimum.

Mount Rogers is the fourth locality reported for this form, and it is probably more abundant there than at any other place. Only a dozen or so specimens have been taken altogether on White Top, thus its abundance on Mount Rogers is the more interesting, particularly in view of the fact that we covered such a small area.

Gyrinophilus sp.

One larval specimen, U.S.N.M. no. 124487. This individual was found in the stream noted above under *D. q. quadramaculatus* and was but one of several seen in this and the rivulet where *D. f. fuscus* was secured. We expended several hours in a particular attempt to obtain adults, which seem to have escaped the efforts of White Top collectors as well. One would expect the adults, from geographic probability, to be *Gyrinophilus danielsi*. An attempt which was made to raise the larva to transformation was unsuccessful. Collectors who visit the Balsams in the future should make special efforts to obtain adult specimens.

Eurycea bislineata wilderae Dunn

Two adults, U.S.N.M. nos. 124484, 124629, were taken, of which one was found under a rock in a marshy area at about 4,900 feet on the east side of the top. The second example was discovered in a thick leaf pile along the side of the creek mentioned above under *D. q. quadramaculatus*.

ORNITHOLOGY.—*The races of the silver-breasted broadbill,* Serilophus lunatus *(Gould)*.[1] H. G. DEIGNAN, U. S. National Museum.

Through the kindness of the authorities of the Chicago Natural History Museum (C.N.H.M.), the Academy of Natural Sciences of Philadelphia (A.N.S.P.), and the American Museum of Natural History (A.M.N.H.), I have been enabled to add to the series of the silver-breasted broadbill in the United States National Museum (U.S.N.M.) to make a total of 93 specimens.

From the taxonomic point of view, this has proved to be a highly unsatisfactory species. While the races may be immediately broken into three main groups, in accordance with the color of the lores (black, rusty, or ashy), further subdivision hinges upon such subtle factors as the extent and intensity of tones of gray and brown and is complicated by a certain degree of individual variation in almost any given character. Thus, while subspeciation appears in all the zoogeographic areas where such might be expected, yet it is a matter of the greatest difficulty to set forth intelligible diagnoses, even when these apply, not to individuals, but to series. In the diagnoses given below, only characters that possess subspecific importance will be noted; it may be said at once that no consequential variation has been found in measurements or in the complicated patterns of wing and tail.

With the understanding that *Serilophus rubropygius* (Hodgson) represents a closely allied but independent species, I find the following populations of *S. lunatus* apparently worthy of nomenclatorial recognition:

[1] Published by permission of the Secretary of the Smithsonian Institution. Received July 18, 1947.

1. **Serilophus lunatus polionotus** Rothschild

Serilophus lunatus polionotus Rothschild, Bull. Brit. Orn. Club **14**: 7. Oct. 30, 1903 (Mount Wuchi, Hainan).

Diagnosis.—The lores black; the sides of the head and the ear coverts pale ashy ferruginous; the forehead pale ashy gray, this color changing insensibly to the pale ashy ferruginous of the crown and nape; the scapulars and upper back ashy gray; the lower back rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Hainan.

Specimens examined.—HAINAN: Mount Wuchi (10 males, 3 females).

2. **Serilophus lunatus elisabethae** La Touche

Serilophus lunatus elisabethæ La Touche, Bull. Brit. Orn. Club **42**: 14. Oct. 29, 1921 (Hokow, elev. 300 feet, southeastern Yunnan Province, China).

Diagnosis.—The lores blackish; the sides of the head and the ear coverts pale ferruginous; the forehead pale ashy, this color changing insensibly to the ferruginous of the crown and nape; the scapulars and upper back deep ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—The valley of the Red River from the Chinese frontier to its mouths and thence southward into northern Annam.

Specimens examined.—YUNNAN: Southeast: Hokow (1 female); ANNAM: Thanhoa Province: Lunglunh (2 males); Vinh Province: Phuqui (1 female).

3. **Serilophus lunatus impavidus,** n. subsp.

Type.—C.N.H.M. no. 90275, adult male, collected at Thateng (lat. 15°31′ N., long. 106°22′ E.), Saravane Province, Bas-Laos, on December 6, 1931, by Jean Delacour (original number 743).

Diagnosis.—The lores black or blackish; the sides of the head and the ear coverts pale ferruginous; the forehead pale ashy, this color changing insensibly to the light ferruginous of the crown and nape; the scapulars and upper back brownish ashy; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Bas-Laos (Boloven region).

Specimens examined.—BAS-LAOS: Saravane Province: "Boloven Plateau" (1 male), Thateng (4 males, 4 females), Ban Kok (1 male), Pakse (1 male, 1 female).

Remarks.—This race is very near to *S. l. elisabethae*, with which it has been heretofore confused, but is easily distinguishable, especially in series, by the predominantly ashy hue of the scapulars and upper back. Certain examples of true *elisabethae* seem to approach it in this respect but prove to be less well-made skins, in which the grayish *bases* of the feathers are exposed to view. In series also the reds of crown, nape, lower back, rump, upper tail coverts, and innermost secondaries average slightly paler in *impavidus* than in *elisabethae*.

4. **Serilophus lunatus aphobus,** n. subsp.

Type.—U.S.N.M. no. 330375, adult male, collected on Khao Laem (a mountain of the San Kamphaeng Range at lat. 14°25′ N., long. 101°30′ E.), at the southwestern corner of the eastern Siamese Plateau, on December 28, 1930, by Hugh M. Smith (original number 4432).

Diagnosis.—The lores blackish rusty; the sides of the head and the ear coverts ferruginous; the forehead pale ashy, this color changing insensibly to the light ferruginous of the crown and nape; the scapulars and upper back ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Eastern Siam.

Specimens examined.—SIAM: East: Ban Lam Thong Lang (1 male), Khao Laem (1 male, 1 female).

Remarks.—The present form is similar to both *S. l. elisabethae* and *S. l. impavidus*, but separable from either by having the lores blackish rusty instead of black, and the sides of the head and ear coverts a rather more vivid ferruginous. The color of the scapulars and upper back is intermediate between those of *elisabethae* and *impavidus*.

A male from Khao Soi Dao and another from Ban Bang Phra, localities in extreme southeastern Siam, are near *aphobus* but have the reds slightly deeper in tone. For the present they must be left unnamed.

5. **Serilophus lunatus atrestus,** n. subsp.

Type.—A.M.N.H. no. 143346, adult male, collected at Mengting (lat. 23°33′ N., long. 99°05′ E.), western Yunnan Province, China, on February 19, 1917, by Roy C. Andrews and Edmund Heller (original number 492).

Diagnosis.—The lores blackish rusty; the sides of the head and the ear coverts bright ferruginous; the forehead pale ashy, this color changing insensibly to the bright ferruginous of the crown and nape; the scapulars and upper back ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Northeastern Burma; Northern and Southern Shan States; western Yunnan; Haut-Laos; Tongking (west of the Black River-Red River divide); northern Siam (eastern provinces.)

Specimens examined.—YUNNAN: West: Mengting (1 male); SOUTHERN SHAN STATES: Kengtung State: Mong Len (1 male); SIAM: Northeast: Muang Lom Sak (1 male); HAUT-LAOS: 5° Territoire Militaire: Muong Yo (2 males, 2 females); TONGKING: Laichau Province: Muong Mo (1 male).

Remarks.—This race is distinguishable in series from *S. l. aphobus* by the more vivid

tones of the reds of the sides of the head, ear coverts, and upper parts.

From *S. l. elisabethae* it may be separated by having the lores blackish rusty instead of black, and by having the reds of the sides of the head, ear coverts, and upper parts distinctly lighter and brighter.

6. Serilophus lunatus lunatus (Gould)

Eurylaimus lunatus Gould, Proc. Zool. Soc. London **1** (12): 133. Apr. 16, 1834 ("apud Rangoon"; type locality here restricted to the hills of the Pegu District, Pegu Division, Burma).

Eurylaimus lunatus Gould, Trans. Zool. Soc. London **1** (2): 176, pl. 25. Apr. 23–25, 1834 ("apud Rangoon, Peninsulæ Indiæ ulterioris").

Diagnosis.—The lores rusty or blackish rusty; the sides of the head and the ear coverts ferruginous; the forehead pale ashy, this color changing insensibly to the light ferruginous of the crown and nape; the scapulars and upper back ashy brown; the lower back rufescent, this color changing to chestnut-rufous on the rump and upper tail coverts; the innermost secondaries rufous-buff.

Range.—Pegu Yomas; Karenni; Tenasserim (south to the Amherst District); northwestern Siam (including Chiang Rai Province).

Specimens examined.—SIAM: Northwest: Chiang Saen Kao (1 male, 2 females), Wiang Khae (1 female), Ban Muang Sum (1 male), Doi Pha Hom Pok (1 male, 1 female), Doi Hua Mot (1 male, 2 females), Doi Chiang Dao (1 male, 2 females), Doi Suthep (1 male, 2 females), Doi Khun Tan (1 male, 2 females); TENASSERIM: Salween District: Papun (1 male).

Remarks.—The population I have taken to represent *S. l. lunatus* is immediately separable from all except the next following by the pale coloration of its innermost secondaries.

It must be said, however, that no topotypical material has been available to me, and the assumption that the bird of Pegu is the same as that of northwestern Siam rests only upon zoogeographical probability. The colored portrait of "*lunatus*" in Gould's *Birds of Asia* is, as observed by Hume (Stray Feathers **3**: 53. 1875), altogether too brightly colored; that given in the Trans. Zool. Soc. London could as easily picture the race described below from southwestern Siam.

7. Serilophus lunatus intrepidus, n. subsp.

Type.—A.M.N.H. no. 203342, adult female, collected 28 miles southeast of Ban Um Phang (a village at lat. 15°47′ N., long. 98°50′ E.), southwestern Siam, on February 2, 1924, by Arthur S. Vernay (original number 611).

Diagnosis.—The lores rusty or blackish rusty; the sides of the head and the ear coverts ferruginous; the forehead pale ashy, this color changing insensibly to the light ferruginous of the crown and nape; the scapulars and upper back ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries rufous-buff.

Range.—Southwestern Siam and the adjacent parts of Tenasserim (Amherst and Tavoy Districts).

Specimens examined.—TENASSERIM: Amherst District: "Thaungyin valley" (1 male), "Thoungyin" (1 male), Moulmein (1 male), headwaters of the Mepale Chaung (1 female), Mitan (1 male); SIAM: Southwest: 17 miles east of Lakya, Tenasserim (1 female), 28 miles southeast of Ban Um Phang (1 male, 1 female), 20 miles west of Muang Kamphaeng Phet (1 female).

Remarks.—*S. l. intrepidus* is distinguished from all races except *lunatus* by the light-colored innermost secondaries. From *lunatus* itself it is separable only by the richer coloration of the posterior upper parts, in this showing normal intergradation between the more northern form and *S. l. stolidus.*

It is probable that the differentiating character of the race would appear more strongly in specimens from more southerly localities; in default of such material, I have selected as type locality the most southern provenience represented in my series.

8. Serilophus lunatus stolidus Robinson and Boden Kloss

Serilophus lunatus stolidus Robinson and Boden Kloss, Bull. Brit. Orn. Club **40**: 16. Dec. 8, 1919 (Khao Nong, a mountain in peninsular Siam at lat. 8°55′ N., long. 99°38′ E.).

Diagnosis.—The lores ashy rusty; the sides of the head and the ear coverts ashy ferruginous; the forehead and forecrown pale ashy, this color changing insensibly to the pale ashy ferruginous of the hindcrown and nape; the

scapulars and upper back ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Peninsular Siam (south of lat. 11°40′ N.); Tenasserim (Mergui District).

Specimens examined.—Siam: Peninsula: Khao Luang, at lat. 11°40′ N., long. 99°35′ E. (1 female), Khao Luang, at lat. 8°30′ N., long. 99°45′ E. (3 males).

Remarks.—Compared with "*lunatus*" from the Isthmus of Kra, Robinson and Boden Kloss found that *stolidus* had "deeper-coloured inner secondaries and tertiaries" and "slightly more drab, less fulvous ear coverts." One would not ordinarily expect isthmian examples (lat. 10° N.) to differ in any important way from those of Khao Nong (lat. 8°55′ N.), and the fact that the single specimen from lat. 11°40′ N. is indistinguishable from those of lat. 8°30′ N. seems to show that only one race occurs in the Siamese portion of the Peninsula.

9. **Serilophus lunatus rothschildi** Hartert and Butler

Serilophus rothschildi Hartert and Butler, Bull. Brit. Orn. Club **7**: 50. May 25, 1898 (Gunong Ijau, elev. 3,000 feet, Perak State, Malaya).

Diagnosis.—The lores pale ashy; the sides of the head and the ear coverts ashy or brownish ashy; the forehead and forecrown pale ashy, this color changing insensibly to the brownish ashy or ashy brown of the hindcrown and nape; the scapulars and upper back deep ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Malaya (northern Perak to southern Selangor).

Specimens examined.—Malaya: Perak State: Gunong Ijau (2 females); Selangor State: Ginting Bidei (2 females).

10. **Serilophus lunatus moderatus** Chasen

Serilophus lunatus moderatus Chasen, Treubia **17** (2): 137. July 1939 (Palok, near Mount Leuser, elev. *ca.* 1,000 meters, Achin, northern Sumatra).

Diagnosis.—The lores blackish ashy; the sides of the head and the ear coverts ashy or brownish ashy; the forehead and forecrown pale ashy, this color changing insensibly to the brownish ashy or ashy brown of the hindcrown and nape; the scapulars and upper back deep ashy brown; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Northern Sumatra (Achin).

Specimens examined.—Sumatra: North: Bandar Bahru (1 male), Blangnanga (2 males, 2 females), Blangbeke (1 male, 1 female), Kungke (1 female).

Remarks.—This form seems to be separable from *rothschildi* only by its darker lores.

11. **Serilophus lunatus intensus** Robinson and Boden Kloss

Serilophus lunatus intensus Robinson and Boden Kloss, Journ. Straits Branch Roy. Asiat. Soc. **73**: 276. July 1916 (Siolak Dras, Korinchi Valley at elev. 3,100 feet, southwestern Sumatra).

Diagnosis.—The lores blackish ashy; the sides of the head and the ear coverts brownish ashy; the forehead and forecrown pale ashy, this color changing insensibly to the brownish ashy or ashy brown of the hindcrown and nape; the scapulars and upper back deep ashy brown, lightly suffused with rufous; the lower back chestnut-rufous, this color changing to rufous-chestnut on the rump and upper tail coverts; the innermost secondaries chestnut-rufous.

Range.—Sumatra (excepting Achin).

Specimens examined.—Sumatra: Southwest: Siolak Dras (2 males, 1 female).

Remarks.—Meyer de Schauensee and Ripley (Proc. Acad. Nat. Sci. Philadelphia **91**: 336. 1940) have combined *moderatus* with *rothschildi* but have kept *intensus* as a "thin" race, barely separable from their *rothschildi-moderatus*. All Sumatran birds seen by me, however, are easily distinguishable from true *rothschildi* by the color of the lores. To my eyes, the real problem is to divide *moderatus* from *intensus*, and this seems to be just possible in series by the tone of the brown of the scapulars and upper back.

PROCEEDINGS OF THE ACADEMY

Meeting of Executive Committee

The Executive Committee met in the Cosmos Club at 8:10 P.M. on February 2, 1948, to consider the budget submitted by the Treasurer. The President, F. D. Rossini, presided; others present were: H. S. Rappleye, Walter Ramberg, W. L. Schmitt, and C. L. Gazin. After careful consideration of the separate items, the Committee unanimously approved the following budget for 1948:

Item		*Amount*
Operating Expenses:		
Meetings Committee	$ 500	
Secretary	400	
Treasurer	250	
S. M. & C. of Pubs.	50	$1,200
Journal:		
Printing, mailing, illustrations, & reprints	$4,776	
Editorial Assistant	300	
Miscellaneous	50	5,126
Total expenditures		$6,326
Estimated receipts		6,144
Deficit		$ 182

In view of the evident deficit the Committee turned its attention to ways and means of increasing the Academy income so that running expenses in the future might be met from yearly income without depleting the invested assets. Discussion was centered about two means: increasing the number of paying members and initiating a drive for Journal subscriptions.

About 18 vacancies exist in the Academy membership, and an informal discussion the Committee showed agreement in favor of raising the limit of membership to permit a greater income from this source.

With regard to the possibility of obtaining additional funds from new subscriptions, the Secretary was instructed to inform the Custodian and Subscription Manager of Publications that the Executive Committee is desirous of having the Subscription Manager attempt to secure these subscriptions through distribution of approximately 100 copies of an appropriate issue of the Journal, each with a reprint of the index of the Journal for 1947 and a covering letter to various university and scientific institution libraries in this country and abroad not now subscribing to the Journal.

The meeting was adjourned at 9:55 P.M.

C. L. Gazin, *Secretary.*

Obituary

Robert Hamilton Lombard was born in Ashburnham, Mass., on December 3, 1887, and died on October 11, 1947. He was graduated from Cushing Academy in Ashburnham in 1906, and from Massachusetts Institute of Technology in 1910 with the S.B. degree. While at M.I.T. he was research assistant in physical chemistry. He published papers with Prof. M. DeKay Thompson and Prof. A. A. Noyes, under whom he worked. He obtained his Ph.D. degree at Columbia University in 1915 in chemistry and was an instructor there. He published two papers with Prof. Alexander Smith, one dealing with phosphorus pentachloride and the other with ammonium halides.

From 1915 to 1927 Dr. Lombard was employed as a chemist in the Geophysical Laboratory of the Carnegie Institution of Washington, where he conducted research on the system copper-iron-sulphur. He published three papers on this work, with E. T. Allen and H. E. Merwin as co-authors.

For the last 20 years Lombard was a research chemist in the Norton Company, Research Laboratories, at Worcester, Mass. He made important contributions to the abrasive industry, and a number of patents, both domestic and foreign, have been granted covering his developments. Most of his researches were connected with the vitrified bonding of grinding wheels and other abrasive products. The most important new product resulting from his work is a grinding wheel having diamonds as the abrasive grains and a new-type vitrified bond. This product is superior to resinoid bonded and metal bonded diamond wheels in that the diamonds are held more firmly and efficiently while, at the same time, a freer cutting action is obtained.

Dr. Lombard was a member of the honorary scientific societies Sigma Xi and Phi Lambda Upsilon. He was a member of the American Chemical Society, the Washington Academy of Sciences, the American Fern Society, and the Worcester Chemists' Club and was a fellow of the American Association for the Advancement of Science. His hobbies included botany and photography, and he had a collection of fine cameras. He was a member of the First Baptist Church of Worcester.

He is survived by his wife, Hazel Soule Lombard, and a 12-year old daughter, Anne.

L. H. Milligan.

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JOURNAL

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BIOCHEMISTRY.—*The chemical nature of enzymes.*[1] JAMES BATCHELLER SUMNER, Cornell University. (Communicated by WALDO L. SCHMITT.)

Why was it difficult to isolate an enzyme? Here I employ the word "isolate" as meaning preparing in pure condition. It does not seem difficult to isolate and crystallize an enzyme now, but it was difficult 20 years ago. The reasons were several. One was the inertia of men's ideas. Another reason was the influence exerted by Willstätter and his school, who held that enzymes were neither lipids, carbohydrates, nor proteins and who believed enzymes to exist in excessively low concentrations in plants and animals. The misconception that colloidal substances had a chemistry different from that of crystalloids was another stumbling block. A yet more important reason why enzymes could not be isolated readily was because work with these substances requires a special technique. The enzyme is present in relatively low concentration in the raw material. It often is highly unstable. The raw material nearly always contains natural protectors which are left behind during the purification processes. In the absence of these natural protectors, the enzyme may become destroyed by traces of heavy metals, by oxidation, by unfavorable pH, or even by autolysis.

I wish to tell next why I decided in 1917 to attempt to isolate an enzyme. At that time I had little time for research, not much apparatus, research money, or assistance. I desired to accomplish something of real importance. In other words, I decided to take a "long shot." A number of persons advised me that my attempt to isolate an enzyme was foolish, but this advice made me feel all the more certain that if successful the quest would be worth while.

The reasons why I chose to work with urease were several. I had been working with urease as a reagent for the estimation of urea in muscle, blood, and urine. This urease was prepared from soy bean meal. In 1916, Mateer and Marshall found that the jack bean, *Canavalia ensiformis*, contained about 16-fold more urease than the soy bean. The jack bean appeared to me to be extraordinarily rich in urease and I could see no reason why this enzyme could not be isolated in pure form and characterized chemically. Claude Bernard has said that success or failure may depend upon the lucky choice of some reagent or raw material. Willstätter was unfortunate in his choice of saccharase as an enzyme to isolate. I was fortunate in choosing urease.

I hoped that urease would turn out to be a globulin, since globulins usually, if not always, are present in beans and seeds, and since globulins are easy to precipitate by dialysis. Other reasons for choosing urease as the enzyme to isolate were that this enzyme can be estimated quantitatively very accurately and readily, and that urease could be expected to be one enzyme, rather than a mixture of enzymes, acting as it does on such a simple substrate as urea.

I started trying to isolate urease in the fall of 1917, having been occupied previously with analytical methods. At this time, our laboratory contained no adequate apparatus for grinding jack beans. We first used a coffee mill and then ground the coarse material with a mortar and pestle. Years later, we constructed a mill which was run by an electric motor and which

[1] Nobel Laureate Lecture delivered at Stockholm, Sweden, December 12, 1946. Previously published by the Royal Academy of Sciences, Stockholm.

employed a bolting device, However, in the meanwhile we usually used commercial jack bean meal. This commercial meal was not always satisfactory.

The jack bean is a miniature world in itself and contains all of the elements required for life, growth, and reproduction. I decided to isolate and characterize as many as possible of the chemical compounds present in the bean. I found various minerals, proteins, carbohydrates, lipids, extractives, pigments, and enzymes to be present. Particular attention was paid to the proteins of the jack bean, since I expected to find that urease was one of these. I isolated two globulins in crystalline form and named these concanavalin A and concanavalin B. A third globulin which I called "canavilin" separated as spheroids upon dialysis. Years later Howell and I were able to crystallize this, after a preliminary digestion with trypsin. Many years later we discovered that concanavalin A is a hemagglutinin for the red cells of certain animal species as well as an excellent precipitant for certain polysaccharides. A lipid fraction of the jack bean was observed to function as a thromboplastic agent.

In attempting to concentrate and purify urease, I employed fractional precipitation with alcohol, acetone, and other organic solvents. Fractional precipitation with ammonium sulfate, magnesium sulfate, and other neutral salts was tried. I tested a large number of salts of heavy metals or precipitants. I employed a very large number of reagents as absorbents. This work covered many years. At times I grew discouraged and temporarily abandoned the quest, but always returned to it again.

At first we used to extract urease from jack bean meal with water. These aqueous extracts were viscous and therefore very difficult to filter. Glycerol extracts were even more bothersome. I learned that Folin used 30 percent alcoholic extracts of jack bean meal as a source of urease for analytical purposes. It was found that extraction with 30 percent alcohol was of distinct advantage, inasmuch as this solvent dissolved most of the urease but failed to dissolve a rather large quantity of the other proteins. Hence, a considerable purification was achieved through the use of this solvent. The alcoholic extracts filtered very rapidly, leaving the undissolved material behind on the filter paper. The only disadvantage of 30 percent alcohol lay in the slow inactivating action of this solvent upon the urease. However, if kept at low temperatures, there was no inactivation of the enzyme.

When kept at low temperatures, 30 percent alcoholic extracts of jack bean meal formed precipitates. These precipitates contained practically all of the urease, together with concanavalin A, concanavalin B, and other proteins. At this time we had no ice chest in our laboratory and we used to place cylinders of 30 percent alcoholic extracts on our window ledges and pray for cold weather.

It seemed to me of interest to employ dilute acetone instead of 30 percent alcohol and to see whether this substitution would result in any improvement in the method of purification. Accordingly I diluted 316 cc of pure acetone to 1,000 cc and used this as the means of extracting the urease. I routinely employed this dilution of acetone, since I had been preparing 30 percent alcohol through diluting 95 percent alcohol in this manner. The acetone extract was chilled in our newly acquired ice chest overnight. The next morning I examined the filtrate. It contained practically no precipitate, thus differing from alcoholic filtrates. However, upon observing a drop of the liquid under the microscope, it was seen to contain many tiny crystals. These were of a shape that I had never observed previously. I centrifuged off some of the crystals and observed that they dissolved readily in water. I then tested this water solution. It gave tests for protein and possessed a very high urease activity. I then telephoned to my wife, "I have crystallized the first enzyme."

Now I should like to tell this audience what enzyme crystals look like. This description applies also to proteins, since enzymes are proteins. Enzyme crystals are nearly always microscopic, since these compounds, being of high molecular weight, diffuse relatively slowly and therefore crystallize slowly. Enzyme crystals belong

nearly always to the isometric or hexagonal systems. Sometimes enzymes separate from solution as spheroids. This formation indicates a tendency to crystallize, as Dr. Northrop can tell you from his experience. Spheroids are nearer the crystalline state than purely amorphous material, such, for example, as casein which has been precipitated from milk by the addition of acetic acid. Spheroids have sometimes been found by us to be aggregations of many needles either in parallel or concentrically arranged.

Having convinced myself that I really had isolated urease in crystalline form, I read a paper on this matter at Clifton Springs, N. Y., and published an article in the August number of the Journal of Biological Chemistry for the year 1926. But now a difficulty arose. The commercial jack bean meal which we had been using suffered a decline in quality and we could obtain no urease crystals from it unless we added a small amount of acetic acid to the alcoholic filtrates. Even then, the yield of crystals was low. Analyses showed that the recent samples of jack bean meal contained only about one-half as much urease as the earlier samples. Accordingly, attempts were made to obtain satisfactory meal, or satisfactory jack beans. We grew jack beans in one of the Cornell greenhouses. The beans grew poorly and the yield was less than the number of beans planted. We obtained jack beans from Texas, Guatemala, and Honduras, but these were low in urease. I happened to meet a plant physiologist, Dr. Albert Muller, who said he would grow me some jack beans at Mayagüez, Puerto Rico. I gave him about a kilo of jack beans rich in urease, the last I had left. Some seven months later about a bushel of beans arrived from Puerto Rico. These beans were rich in urease. The finely ground meal gave a high yield of urease crystals. Later we were able to obtain excellent jack beans from an Arkansas farmer. He has supplied us with jack beans ever since.

I wish to speak now about proofs of the identity of the crystals with urease. In cases of this sort, one piece of experimental evidence is not sufficient to constitute a valid and satisfactory proof; one must submit many pieces of evidence. At this time I had no access to the ultracentrifuge of Svedberg nor to the electrophoresis apparatus of Tiselius. However, I was able to offer evidence of another sort, as is shown below:

1. When the crystals separated there occurred a great increase in purity, namely from 700 to 1,400-fold. Using other methods the increase in purity observed was very much less than this and at times there even occurred a decrease in purity.

2. When the distribution of urease was followed quantitatively it was found that of the urease passing into the filtrate as much as 40 percent or more separated with the crystals.

3. Recrystallization increased the purity of the urease.

4. Adding traces of poisons, such as mercuric chloride or formaldehyde, to jack bean meal inactivated the urease and, at the same time, prevented the appearance of the crystals.

In obtaining the crystals, I felt much the same as a person does who is trying vainly to place in position a piece of a machine. Suddenly the piece slides in as if covered with butter. One knows that it is now where it belongs.

During later work on crystalline urease, I was fortunate to have a number of excellent men in our laboratory. These were Doctors Hand, Kirk, Poland, and Dounce. We found that trypsin neither digested nor inactivated urease. Since trypsin is a proteolytic enzyme of second attack, it does not digest certain native proteins readily. Some proteins that are digested with great difficulty are hemoglobin, ovalbumin, and the serum proteins. After urease had been denatured by acid or by heating, it was found to be very readily digested by trypsin.

Pepsin acts best in a strongly acid medium and strong acid rapidly destroys urease. However, at pH 4.3 we found that urease was so slowly destroyed that it was possible to demonstrate a parallel digestion and inactivation by pepsin. In place of pepsin it was possible to use papaincysteine.

In our laboratory Dr. J. Stanley Kirk was able to immunize rabbits to crystalline urease. Kirk started by giving rabbits as little as 0.03 mg of crystalline urease intra-

peritoneally. This dose was given twice weekly and was finally increased to 1,000 lethal doses. The immunized rabbits contained antiurease in their blood serum. This antiurease could be purified by precipitating it by adding urease, washing the urease-antiurease precipitate, decomposing the complex with 0.05 N hydrochloric acid, bringing to pH 5.0, and centrifuging down the denatured urease. The antiurease was not harmed by this treatment and could be employed as an excellent precipitant in testing for urease. It gave a visible precipitate with solutions of urease diluted 1 to 500,000. However, urease allowed to stand for a few seconds with 0.05 N hydrochloric acid and then neutralized gave no precipitate with antiurease; neither did it possess any urease activity.

Northrop has made good use of physical methods to demonstrate the identity of pepsin with his pepsin crystals. While we have not employed such methods, Kubowitz and Haas, working in Warburg's laboratory, have demonstrated that ultraviolet light is absorbed by highly dilute solutions of crystalline urease and that exactly the same wavelengths that are absorbed are those which destroy urease.

In 1930, Northrop of the Rockefeller Institute obtained pepsin in crystalline form. A short time later, Northrop and Kunitz obtained crystalline trypsin, crystalline chymotrypsin, and also the zymogens of these enzymes in crystalline form. Their monumental work was of very great help in bringing the scientific world to admit that enzymes can be isolated in pure and crystalline condition. In this connection I wish to note that Professor von Euler aided me greatly when I worked on urease in his laboratory at Stockholm's Högskule in 1929 and that I received valuable help in 1937 while working in the laboratory of Prof. Thé Svedberg at the University of Upsala.

The announcement of the crystallization of urease and pepsin was not accepted by some biological chemists. In Germany students of Willstätter attempted to show that our crystalline proteins were merely carriers of the enzymes. It suffices to say that these attempts to disprove our work failed, as they were bound to fail, since Northrop and I were right and since our evidence was unassailable.

To date about thirty enzymes have been obtained in crystalline and in presumably pure condition. Certain enzymes are colored, being combinations of specific proteins with such prosthetic groups as riboflavin, phosphate, or hematin. Theorell has crystallized the yellow enzyme of Warburg and Christian and, remarkably enough, has been able to split the protein from the riboflavin phosphate and later to reunite these two components. He has shown conclusively that the union of these components proceeds stoichiometrically.

The enzymes catalase and peroxidase are compounds of protein with hematin and these two enzymes possess characteristic absorption bands. This property has greatly facilitated the crystallization of these two enzymes. In addition, it should be noted that these two enzymes have been shown to form compounds with hydrogen sulfide, sodium fluoride, sodium azide, etc.

All enzymes are proteins but not all proteins are enzymes. Many, if not all enzymes can be crystallized. The oxidizing enzymes all appear to be conjugated, or compound, proteins, while the hydrolytic enzymes are, as far as we can tell, without prosthetic groups. However, even hydrolytic enzymes must have reactive groups. Every enzyme requires a specific method for its purification. Our present methods of purifying both enzymes and proteins are crude and unsatisfactory for the most part. It is fairly certain that better methods will be discovered in the near future. One can purify an enzyme either by precipitating the impurities or else by precipitating the enzyme. The latter procedure is to be preferred, but the former procedure often is necessary at the beginning. When I speak of precipitating the enzyme I mean, of course, a more or less specific precipitation and not a general precipitation of everything, much as occurs on adding a great excess of alcohol or acetone.

Some day every enzyme in living matter will have been discovered and described. Every chemical reaction which goes on will have been recorded. We probably can ex-

pect to find some enzymes which are glycoproteins, others which are lipoproteins, and others which are nucleoproteins.

In 1917, the role played by enzymes was only partially understood. Digestive enzymes were well known, autolytic and oxidative enzymes were somewhat known, but not well understood. At present we realize the tremendous complexity of the cell. In muscle alone, some 60 enzymes are known to occur. Thanks to relatively recent investigation, practically all of the complicated reactions involved in the breaking down of glycogen to carbon dioxide and water have been made clear.

The organic chemist has never been able to synthesize cane sugar, but, by using enzymes, the biological chemist can synthesize not only cane sugar, but also gum dextran, gum levan, starch, and glycogen.

We know now of the existence of enzymes which employ phosphoric acid instead of water and which might be given the general term "phosphorases." There are the phosphorylases, transphosphorylases, phosphoisomerases, phosphomutases, and phosphodismutases.

From the work of Cori and his associates, we now have evidence that hormones function through their effect on enzymes. Thus, glucose is transformed into glucose-6-phosphate when it reacts with ATP in the presence of the enzyme known as hexokinase. This reaction, essential for utilization of glucose, is inhibited by the diabetogenic hormone coming from the anterior pituitary. This inhibiting action is abolished by insulin.

We can sum up by saying that, as the result of discoveries in the field of enzyme chemistry, some questions have been answered and many new questions have arisen. We live in an expanding universe in more senses than that of the astronomers.

In conclusion, I wish to pay tribute to my former teacher, Otto Folin, who emigrated as a boy of 17 from Småland to America and who, as professor of biochemistry at Harvard, inspired me as he did many other young men.

CHEMISTRY.—*Dr. Stephen Brunauer's contributions in the field of adsorption.*[1]

Ralph A. Beebe, Amherst College. (Communicated by James I. Hoffman.)

At the outset I think it is desirable to distinguish clearly between physical adsorption and chemisorption, and with that in view I have tabulated below a number of characteristics of each type of process:

Physical Adsorption	*Chemisorption*
1. Rapid	Rapid or slow
2. Reversible	Often irreversible
3. Low heat	High heat
4. Non-specific	Specific
5. Multilayer	Monolayer only

Since this comparison should perhaps be discussed in some more detail, attention is called to the following:

1. Physical adsorption is generally a rapid process whenever the surface is readily accessible to the gas or vapor being adsorbed, although one may encounter a slow adsorption when it is necessary for the adsorbate to diffuse into cracks or capillaries to reach the adsorbing surface. Chemisorption, on the other hand, like chemical reactions in general, may be rapid or slow, and frequently displays a temperature coefficient requiring an activation energy of the order of magnitude found in chemical reactions.

2. Physical adsorption is in general reversible, and it is possible to remove the adsorbate from the surface by outgassing at the temperature of adsorption or at slightly elevated temperatures. Chemisorption, on the other hand, may be truly irreversible, indeed to such an extent that the adsorbate can be removed only by chemical action at elevated temperatures. For instance, oxygen chemisorbed on tungsten can be removed only by heating to about 2000°C. Other chemisorbed layers, however, can be removed by less drastic treatment, let us say by outgassing at

[1] Address delivered before the Chemical Society of Washington, March 1946, on the occasion of the awarding of the Society's Hillebrand Prize to Dr. Stephen Brunauer. Dr. Beebe's preliminary congratulatory remarks are here omitted. Received September 24, 1947.

temperatures of a few hundred degrees above that at which the adsorption process takes place.

3. In general, the heat of adsorption which indicates the energy of binding of the adsorbate molecules to the solid surface is of a low order of magnitude in the case of physical adsorption, usually two to three times the heat of vaporization for the first portions of adsorbate added to the surface. This means that for such gases as nitrogen, oxygen, argon, or carbon monoxide, all of which boil at temperatures approximately that of liquid air, the heat of adsorption will not exceed 5 kcals per mole. With larger molecules, such as butane, we encounter higher heats of physical adsorption, which, however, do not exceed 15 to 16 kcals per mole. Again one finds a marked difference in chemisorption, the heats of this process, like those of ordinary chemical reactions, running as high as 100 kcals per mole in certain instances.

4. Although, as is pointed out in Dr. Brunauer's book (*1*), there has never been given an exact definition of the term *specificity* as applied to adsorption, yet this term is of some use in a qualitative sense. It may be said that in the case of physical adsorption the heats evolved tend to be nonspecific to the chemical nature of the gases or vapors involved if these adsorbates have molecular weights, and therefore heats of vaporization, of the same order of magnitude. For instance, one finds that the four substances mentioned above have heats of adsorption of the same order of magnitude. However, we shall see in a later portion of this paper that we must not generalize too far about this nonspecificity of physical adsorption, and that, indeed, significant differences become apparent especially when we study the physical adsorption of the same adsorbate on different surfaces. As might be expected, the heat of adsorption in chemical processes is highly specific and may vary all the way from, let us say, 15 kcals to 100 kcals in different instances. In this respect, of course, chemisorption again resembles chemical reactions in general.

5. It has been well established by the work of Dr. Brunauer and others that the forces which give rise to chemisorption extend to a negligible extent beyond the monolayer of adsorbed molecules. On the other hand the work of the group with which Dr. Brunauer has been associated seems to establish beyond reasonable doubt that we are concerned in physical adsorption with the formation of multilayers of adsorbate on the solid surface (*2*).

With this background, we are now prepared to turn to a discussion and review of of some of the significant work to which Dr. Brunauer has contributed. In making a selection from Dr. Brunauer's experiments, I have chosen the work that has been especially helpful to my own investigations.

In Fig. 1 are shown the isotherms obtained by Emmett and Brunauer (*3*) for the adsorption of carbon monoxide on two iron catalysts at the temperature of liquid oxygen. Looking first at the isotherms for the pure iron catalyst, it is evident that the curve labeled "total adsorption" lies very much above the "physical adsorption" curve. For reasons which have been abundantly established by the group with which Dr. Brunauer has been associated, the points labeled B on each curve represent approximately the completion of the statistical monolayer of physically adsorbed gas. Thus the volume indicated by Point B in the "physical adsorption" curve is the volume of gas required to complete a layer of carbon monoxide molecules in direct contact with the solid surface. The curve labeled "total adsorption" was obtained by outgassing the sample at 400°C and then admitting carbon monoxide to the system at −183°C. After this experiment, the surface was outgassed at −78°, or indeed within the range from −78° to 0°, the temperature of outgassing not being very critical within this range. Following the outgassing process, the adsorption of carbon monoxide was again measured and was found to follow the curve labeled "physical adsorption." Emmett and Brunauer interpreted these experiments to indicate that in the initial experiment the carbon monoxide was adsorbed first as a chemisorbed layer with the carbon monoxide molecules held by relatively strong chemical bonds to the underlying atoms, and next as a physically adsorbed layer on top of the chemisorbed

molecules. On outgassing in the temperature range from $-78°$ to $0°C$, the physically adsorbed molecules were removed, but the thermal energy was insufficient for the removal of the chemisorbed layer, with the result that the extent of physical adsorption could be determined by a subsequent adsorption measurement. It is obvious then that the difference in heights of the two curves represents chemisorption.

From the isotherms for the promoted iron catalyst given in Fig. 1, it is evident again that the two types of adsorption process can be separated. In this case, the relatively large physical adsorption appears to indicate that the small percentage of promoter material present in the catalyst must cover a relatively large fraction of the surface since it is assumed that carbon monoxide is chemisorbed only on that fraction of the surface in which the iron atoms are exposed, but is physically adsorbed on the whole surface. This deduction comprises an important contribution by Emmett and Brunauer to the understanding of promoter action.

Following the completion of these experiments, Dr. Emmett suggested to me that it would be worth while to apply to this problem the technique developed at Amherst for the calorimetric measurement of heats of adsorption. In Fig. 2 are shown the results of these calorimetric experiments (*4*). Emmett and Brunauer, from an interpretation of their curves, would have predicted that the chemisorption process would be superseded by physical adsorption after 0.24 cc and 0.21 cc of carbon monoxide at -78 and $-183°$ respectively had been adsorbed per gram of catalyst. The initial high values in the differential heats of adsorption, of course, indicate chemisorption at $0°$, $-78°$, and even at $-183°$, although the heat values are lower at the latter temperature. The sharp drop in the heats of adsorption at $-78°$ to the region of 4 kcals per mole at 0.25 cc per g, the point predicted by Emmett and Brunauer as a result of the analysis of their isotherms, supplies experimental confirmation of the validity of their interpretations. This confirmation from the heat data at $-183°$, while not so strikingly apparent, is nevertheless seen to be present.

Next we shall turn our attention to another important facet of the work to which Dr. Brunauer has contributed heavily. I refer to the experimental and theoretical development of the theory of multimolecular adsorption, known as the Brunauer, Emmett, and Teller theory (*2*). In the early development of the experimental work, Emmett and Brunauer came to the tentative conclusion that the monolayer is complete at the Point B of the characteristic isotherms obtained in many adsorption systems and illustrated in Fig. 1. This conclusion was found to be consistent with the theoretical considerations developed by Brunauer, Emmett, and Teller. The fundamental equation most generally used is given below:

$$p/v(p_0-p) = \frac{1}{v_m C} + \frac{C-1}{C}\, p/p_0.$$

In this equation, v represents volume of vapor adsorbed, p the equilibrium pressure,

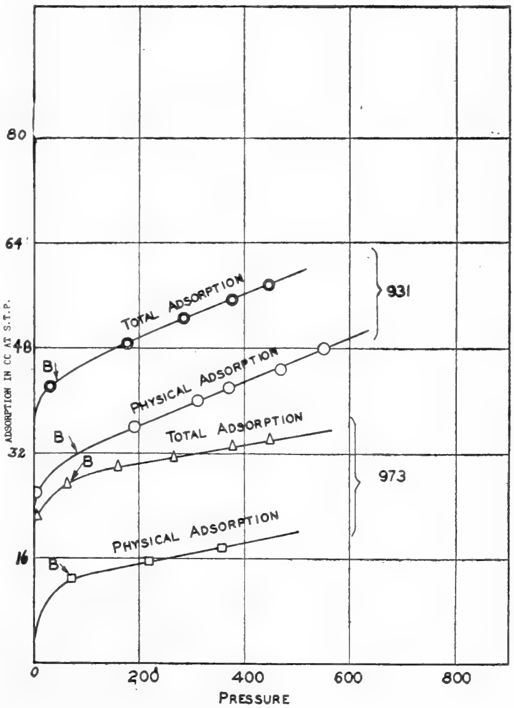

FIG. 1.—Isotherms for CO on iron catalysts at $-183°$: Pure iron catalyst, 973; promoted iron catalyst (K_2O, 1.59 percent, and Al_2O_3, 1.3 percent), 931.

and p_0 the saturation pressure of the vapor at the temperature of the experiment, v_m the volume of gas necessary to fill the monolayer, and C a constant which is approximately defined as $C = e^{(E_1 - E_L)/RT}$ in which E_1 is the heat of adsorption in the first layer, and E_L is the heat of vaporization, and R and T have their usual meaning, E_1, E_L, and R being expressed in calories and T as the absolute temperature. It is apparent that a straight line should be obtained if the function $(p/v(p_0 - p))$ is plotted against p/p_0, and indeed literally scores if not hundreds of cases provide experimental data which conform to this condition. From such a plot, known as the B.E.T. plot, it is possible to obtain the slope and intercept of the straight line, and from these to calculate the values of v_m and of C. Knowing v_m and making an estimate of the area occupied by the adsorbate molecule on the surface, we can calculate the surface area. Obviously such an estimate of surface area, especially on finely divided or porous solids, is a welcome additional technique in the field of adsorption, and as a result has come into very wide use. It will become apparent, I think, in the experiments to be described below, that our ability to estimate the surface area has added greatly to the significance of the interpretation of the experimental results.

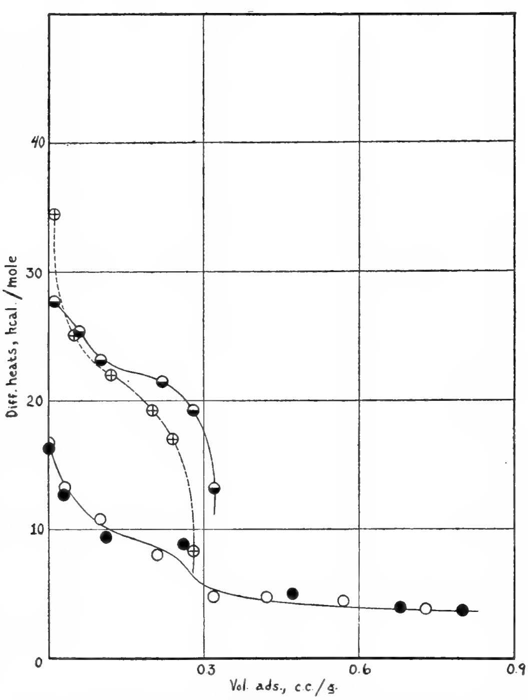

FIG. 2.—Heats of adsorption of CO on catalyst 931: −183°, ○, ●; −78°, ⊕; 0°, ◒.

Now I want to tell you about some work we have been doing in Amherst on the heats of adsorption of vapors on carbon black (*5*). This work was initiated about a year ago as a result of a series of conversations between the writer and Dr. Walter R. Smith of Godfrey L. Cabot, Inc. At that time Dr. Smith was especially interested in getting at the fundamental reasons for the effectiveness of carbon blacks in reinforcing rubber. The investigations in his laboratory had indicated that different carbon blacks presented a very high degree of specificity in their reinforcing ability, especially as determined by the modulus of elasticity. It is apparent, since the carbon black is dispersed through the rubber as particles of the order of several hundred Ångstroms diameter, that the binding forces between the particles of black and the rubber must be adsorption forces between the surface of the blacks and the adjacent sections of the rubber molecules. Following this line of reasoning, one would be tempted to predict that a close correlation might be found between the extent of surface of a carbon black pigment and its reinforcing ability.

That the above prediction is not borne out by the experimental facts is shown in Table 1, which contains data on two samples selected from the several blacks which have been studied; these are labeled Spheron Grade 6 and Graphon respectively. More complete data on these blacks especially as regards the chemical composition of their surfaces and their underlying crystal structure have been published elsewhere (*5*). Spheron Grade 6 is a channel black having good rubber reinforcing ability. The Graphon has been prepared from the Spheron

TABLE 1

Sample	Diameter	Area	Modulus, 300% elong.
	Å	*sq. m./g.*	*lb. sq. in.*
Spheron Grade 6........	285	110	1,720
Graphon..............	300	85	230

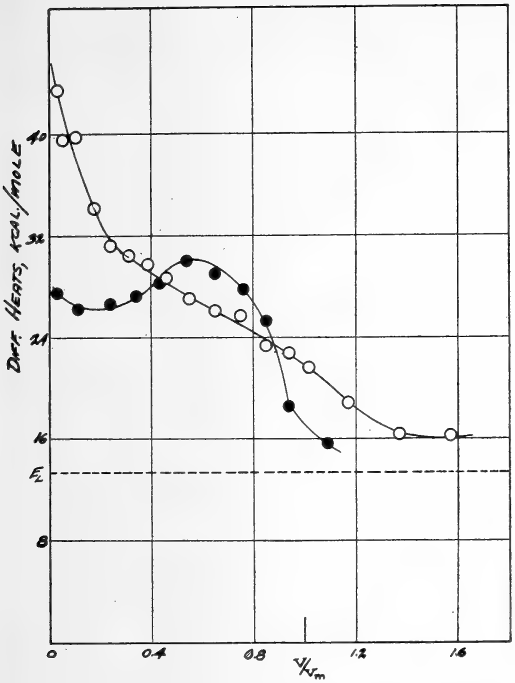

FIG. 3.—Heats of adsorption on carbon blacks at −195°C: N_2 on Spheron Grade 6, ○; N_2 on Graphon ●.

Grade 6 by electrical heating to temperatures of 2,800 to 3,000°C (*6*). As is seen in Table 1, this heating process had relatively little effect on the particle diameters as determined by the electron microscope and on the specific surface areas as determined by the B.E.T. nitrogen adsorption method, although there was a profound effect on the rubber reinforcing ability as indicated by the modulus of rubber samples reinforced by the two pigments.

Although there appeared to be no definite correlation between the extent of surface and the rubber reinforcing ability, it seemed possible that there might be a significant difference in state of surface if the two blacks were compared. Since a convenient means of testing the quality or state of surface of these carbon black samples seemed to be offered by data on heats of adsorption, calorimetric measurements have been undertaken using the elementary gases nitrogen, oxygen, and argon at −195°C (*7*). The results of the experiments with nitrogen are shown in Fig. 3 in which the differential heats of adsorption are plotted against the number of layers adsorbed ($v/v_m = 1$ represents a monolayer).

In relation to the rubber reinforcing problem, the difference in behavior of the Graphon and the Grade 6 black is of great interest. It is apparent that although the high temperature treatment, by which the Graphon was made from the Grade 6 carbon black, resulted in a relatively small change in the total surface of the black, this treatment nevertheless produced a profound change in the energy state of the surface, with the result that approximately the first third of the surface would hold adsorbate molecules considerably less firmly than the original Spheron Grade 6. Thus there appears to be a correlation between the rubber reinforcing abilities of the two blacks and the energy states of their surfaces as indicated by the heats of adsorption.

Apart from the problem of rubber reinforcement several other conclusions of considerable general interest may be drawn from the data of Fig. 3. (1) The order of magnitude of the heats indicates that the process is exclusively physical adsorption. (2) The rapid decrease in the differential

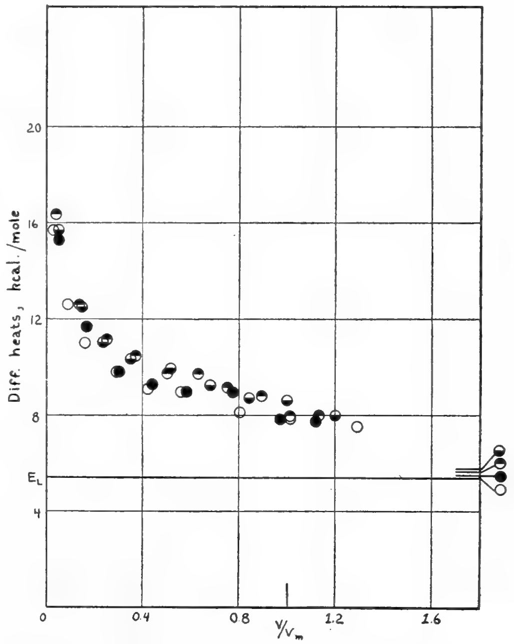

FIG. 4.—Heats of adsorption of Spheron Grade 6 carbon black at 0°C: n-butane, ○; 1-butene, ●; cis-2-butene, ◒; trans-2-butene, ◓.

heats of adsorption for the first parts of the surface covered on the Grade 6 carbon black suggests a considerable heterogeneity of the surface with the fractions first covered exhibiting excessively high binding energies. (3) The rapid approach in the vicinity of $v/v_m = 1$ of the differential heats for nitrogen on all the carbon surfaces studied to values only slightly greater than E_L, the heat of vaporization of nitrogen, provides experimental confirmation of the B.E.T. theory since the value of v_m is determined from the experimental data by a method which is entirely dependent upon this theory.

Calorimetric studies with the elementary gases oxygen and argon produced results entirely analogous to those for nitrogen, the adsorption of both these gases being exclusively of the physical type.

Although the experiments with nitrogen already described have served to bring out differences among the various carbon blacks used, it is obvious that heats of adsorption using hydrocarbons as adsorbates would provide data which would be more closely related to the problem of rubber reinforcement, in which there must be forces in operation between the carbon black surface and adjacent portions of the large hydrocarbon molecule, rubber. For this reason, the next phase of the work to be described involves calorimetric measurements with butane and the butenes as adsorbates at the convenient temperature 0°C. Because each of these substances boils within a few degrees of 0°C, the p_0 value for each is in the vicinity of one atmosphere pressure, and it is convenient to work over the relative pressure range in which the monolayer is completely filled. The results of these experiments are summarized in Fig. 4. In this figure are given the differential heat curves for butane, 1-butene, cis-2-butene, and trans-2-butene on Grade 6 carbon black. It is to be noted that the general shape of the heat curves is similar to that of nitrogen at $-195°$ with the differential heats approaching E_L after the completion of the statistical monolayer. It is noteworthy that there is no great difference in the heats of adsorption of the butane and the unsaturated hydrocarbons. This evidence appears to indicate that the unsaturated sections of the rubber molecule are not necessarily the points at which the rubber is bonded to the carbon surface, and that the adsorption process and possibly also rubber reinforcement involve forces which are primarily physical in nature.

As this talk has progressed, I think it must have become abundantly evident that those of us who have done the heats of adsorption work at Amherst are very greatly indebted to Dr. Brunauer and his coworkers for the pioneer work they have done in the field of adsorption, work which has made our experimental results considerably easier to interpret as a contribution to the fundamental problems of adsorption as well as to the application to rubber reinforcement.

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(3) Emmett and Brunauer. Journ. Amer. Chem. Soc. **59**: 310. 1937; **59**: 1553. 1937; **62**: 1732. 1940.

(4) Beebe and Stevens. Journ. Amer. Chem. Soc. **62**: 2134. 1940.

(5) Beebe, Biscoe, Smith, and Wendell. Journ. Amer. Chem. Soc. **69**: 95. 1947; Beebe, Polley, Smith, and Wendell. Journ. Amer. Chem. Soc., forthcoming.

(6) This high temperature treatment would of course have the effect of removing any volatile matter from the surface of the Grade 6 carbon as well as changing the degree of crystallinity of the underlying solid. Our calorimetric experiments on a sample of Grade 6 black "devolatilized" at 927°C make it more plausible to conclude that the marked difference in the energy states of surface between the Grade 6 black and the Graphon is due to an alteration in the underlying solid by the high temperature treatment rather than to any chemical change in the superficial layers of the pigment (see reference 5).

(7) Details of the experimental method, as well as data on several other blacks and a more extensive discussion are to be found in the publications cited in reference 5.

METEOROLOGY.—*Loose usage of weather words.*[1] W. J. HUMPHREYS.

Fog, haze, visibility, cyclone, blizzard, sleet, drought—what are they? There is no excuse for so using words that they convey no idea whatever or, at most, only vague suggestions of an idea. But frequently they are so used, and for several reasons. The usual reason is the ignorance of the speaker or writer, and the next most common, perhaps, the fact that few indeed practice that best of all courses in rhetoric: "Have something to say; say it; quit talking about it." Of course, an unwilling witness may be consciously vague, and sometimes justly so, but most of us do a lot of talking in our sleep, as it were. And the subject we discuss in vaguest terms is that which concerns us most, and about which we have talked the most since that time when certain things happened in the Garden of Eden "in the cool of the day"—the weather. Even the term "weather" itself is used in the vaguest sort of way, as anyone will realize as soon as he tries to define it accurately.

Not only are we nearly always vague when speaking about weather as a whole, but also, as a rule, we are equally inexact when speaking of any of its elements, or of other phenomena dependent upon or associated with it. For example, *fog* and *haze* are mixed up in a scandalous way despite the great and growing importance of each to the aviator. They often are used as synonymous terms, and again as though a fog were just a dense haze and a haze merely a light fog. Now, they are not the same thing at all and need not often be confused with one another. A true fog is a cloud of water droplets in the space immediately above the surface of the earth—a cloud on the earth. A haze, on the other hand, is a cloud of dust particles of whatever origin, such as impalpable sand caught up by desert winds, the smoke of forest fires, pollen from pine clad mountains, and the like. It may, and commonly does, extend down to the surface of the earth, but it does not always do so. Sometimes, too, its upper surface is as sharply limited and as clearly visible in the direction of the horizon (not vertically) as is that of a waveless ocean.

[1] Received October 10, 1947.

Each decreases visibility. That is why the aviator is so concerned with them. Perhaps, too, as they bother him in much the same way he may feel justified in calling either or both of them by whichever bad name happens to come to his mind first. Indeed they often are so confused, but they do not need to be, for it is quite easy to distinguish between them. The fog droplets are so large that they reflect equally, or nearly so, lights of all colors. It therefore appears white. A large portion of the haze particles, on the other hand, are so small that they scarcely reflect light at all, but just diffuse or scatter it. Furthermore, they scatter the blue, or short-wavelength light, to a far greater extent than they do the longer wavelength, or red light. This being so, the glare that results from the scattered light, and which so greatly reduces visibility, can largely be prevented from reaching the eye by the use of amber, or red, glasses. Clearly, then, the cloudlike obstruction is a dust haze whenever it has a bluish color, and whenever visibility through it is improved by the use of a red or amber screen. Similarly, it almost certainly is a fog when it is white and equally opaque to all colors.

Not only is it generally easy to make this distinction, but frequently it is important to do so, because a fog is likely soon to disappear by evaporation, while a haze hangs on until washed out by rain, thinned by convection, or blown away by clear air.

Visibility.—We have just been glibly using a rather new weather term, visibility, that needs some explanation. It seems to have an obvious enough meaning until we try so to define it that one visibility can be numerically compared with another. Then the trouble begins, for it is hard to say how many times one object is more visible than another. In fact for practical purposes we never define visibility that way, but just say that it is the distance to which objects can be seen, or, better, the greatest distance to which objects of appropriate size can be recognized by a person of average but unaided vision. Evidently visibility is not a distance at all, though dependent on it. Nevertheless, this term with its forced definition is very useful and seems destined

to hold indefinitely an honorable place among the innumerable and growing host of weather words.

It is worth while also to note that there are two quite differently caused visibilities, night visibility and day visibility. The former may be defined as the greatest distance at which a standard light can be seen by a normal, unaided eye. This distance obviously is fixed by the rate of depletion of the light on its way to the observer, since perception fails in this case owing to the feebleness of the light received. Day visibility, on the other hand, is limited mainly by an entirely different cause—not chiefly by depletion of light but by addition of light. When the fog or haze between the observer and distant objects reflects or scatters so much light from the sun, or other sources, as to appear luminous the contrasts of light, by which outlines are perceived and things recognized, soon are lost in the general glare. To repeat, for it is an important distinction, the brighter the light the farther it can be seen. The brighter the day the worse the visibility—the greater the blinding glare.

Fog and cloud.—Not only is fog often confused with haze, to our occasional annoyance, but frequently, too, it is confounded with cloud, and the second of these confusions is the more difficult of the two to disentangle. We may say, and it is quite true, that a fog is a surface cloud formed by surface conditions. But what then shall we call what is left of it when the under portion is burned off, as so commonly happens to sea fog when it drifts in over land? Shall we call it high fog, lifted fog, veillo cloud (the name given to it in southern California), or stratus cloud? All these terms are in good and constant usage, but "stratus cloud" is the best, for that is what the erstwhile fog has now become. Wherever, though, it contacts with the surface, whether water, hill or mountain, it should still be, and generally is, called fog. That is, the same sheet of water droplets is called cloud at one place, where it does not extend to the surface, and fog at another, where it does.

Name of cloud.—And then when we are sure the thing we observe and want to talk about, or record, really is a cloud and not a fog, what sort of a cloud shall we call it, for there are several kinds to which distinct names are given? Way back in the year 1803 an English chemist, or apothecary, as we would say in America, Luke Howard, gave Latin names to several distinct kinds of clouds, names so apt that they soon came into general use in all countries. Later on a few other names were added to the original list until all the more common varieties of clouds had each a distinct designation that seemed entirely appropriate and was clearly defined. But new cloud pictures soon were needed, the old charts being out of print, and this offered an opportunity to revise names and definitions as well. So a committee was appointed for that purpose, a committee that at once began "throwing monkey-wrenches," or so some think, into the erstwhile smoothly running cloud machine. We used to be quite sure, for instance, that a nimbus cloud was one from which rain or snow was falling in quantity, or looked as though precipitation from it was imminent. This was pretty satisfactory, and many of us want to keep the good we have. But no, we are told by this committee that those who feel that they really must retain this life-long name may be graciously permitted to do so provided they pledge to mean thereby only that insignificant little cloud that drifts along in the rain somewhere between the surface of the earth and the base of the heavy cloud out of which the rain is falling. That is, this ancient and honorable name must go out of use altogether, or else be given to that little, unimportant ragamuffin the sailor calls "scud." This is not clarification. It is needless confusion.

Then, too, we felt as certain as one could about anything that the good and appropriate name "cumulo-nimbus" had come to stay and to mean a cumulus (wool-pack or heaped-up) cloud from which rain was falling, and in which thunder and lightning nearly always occur. No. We now are asked to restrict this name to the cumulus cloud whose top has been, or is in the process of being, drawn out into a thin, fibrous sheet. And this in spite of the fact that often a thunderstorm cloud, a cumulo-nimbus as heretofore known, may give much rain and

yet produce no fibrous sheet at all; and in face, of the further fact that occasionally a cumulus cloud may produce no rain, but, for all that, a high sheet of fibrous cloud. For generations we have been accustomed to consider the falling of rain from the base of a cumulus cloud the necessary and sufficient condition for calling it a cumulonimbus. Now we are asked to note whether or not a fibrous cloud is developing out of its top—certainly a radical change of meaning, and a wholly unnecessary one.

It would be well, however, for the aviator to remember that, in middle latitudes, a cumulus cloud that is developing a high fibrous sheet very probably, though not certainly, is also, and at the same time, giving rain below with thunder and lightning; and that the region under a cumulus that has not yet begun to display such a sheet, presumably, but not surely, still is free from rain or other disturbance. To him it is a very real warning flag. Nevertheless, this fact does not in the least justify this change of name, a change that is only confusion confounded—or the other way around.

The next monkey-wrench disarranged the alto-stratus cloud. This term used to mean just what it says—a high layer cloud; that and nothing more. Now we are asked to use this term only when portions of the cloud show some fibrous structure. Here, too, is only confusion, for those who insist on this definition insist, too, that this is the rain-producing cloud. That is, we must call that wide-spread, lightning-free cloud, from which rain is falling abundantly, alto-stratus, and at the same time we must not call it alto-stratus unless we can see in it one or more fibrous patches—thread-bare portions, consisting, we believe, of snow particles. Truly, this puts us in much the same puzzled frame of mind as was Pat when the doctor told him to take one pill three times a day!

The cirro-cumulus cloud is another variety that many of us will insist that we know when we see it, since it is just a field of many little cloudlet balls and ripples (a "mackerel sky" if in orderly rows, a "curdle sky" if the cloudlets are numerous and without order) very high and too tenuous to show evidence of shading, or hide the sun. No, again says our authority, this thing that is a cirro-cumulus cloud must not be called cirro-cumulus unless it has been seen to be formed from a cirrus cloud or cirro-stratus, that is, from a thin or relatively dense cloud, respectively, of fibrous form. Said the yeoman to a yokel: "That is a fine hog of mine over there in the barn lot." "I am not so sure it is a hog," said the yokel. "Why not?" "Oh, I didn't see him grow up from a pig." "Damned fool."

Humidity, a term that comes to mind when we are talking about clouds, is one of the most vaguely used of all weather words. Most of us realize that water is somehow or other involved in its meaning, but just how, when we speak of the air as being humid, is not always clear. Certainly the air is not wet in the sense that our hands become wet when we wash them. Perhaps we can run the trouble down this way: Water can and does exist in the gaseous state as well as in the liquid and solid states. Furthermore, the amount of water that can occupy a given space in the form of a gas, for instance the amount that is in a cubic inch of the "empty" space in a tightly closed bottle containing some water, rapidly increases with increase of temperature. Strange as it may seem, too, this amount is not appreciably affected by the presence of other gases, whether added singly or in whatever combination.

From these facts it is evident that the expression "humidity of the air," or "humidity," for short, can mean any one of at least three different things. To be understood, therefore, one must specify which particular humidity he is talking about. If he just says "humidity" he will be nearly as badly off as the fellow who called for Jones at a Welsh college. "Ah Jones"—most of the windows went up. "Tom Jones"—half of the windows stayed up. "I mean the Tom Jones that has a toothbrush."

If one means, as often is meant, the amount or weight of the water vapor in the air per unit volume he must say "absolute humidity." If, however, as is more often the case, one means the ratio of the amount of water vapor actually present per unit volume to the greatest amount that could

exist in the same volume at the same temperature—the ratio, in brief, of the actual quantity to the saturation quantity—it is necessary to say "relative humidity." Finally, we sometimes mean the weight of the water vapor per unit weight of the moist air, in which case the proper expression is "specific humidity." The term "humidity," as qualified in any one of the above three ways, has a definite and useful meaning; but as commonly used in weather talk it seldom conveys a clear idea to the hearer, and rarely contains a definite concept when it leaves the speaker. Generally, such idea as is associated with this term starts muddled and ends fuddled.

Wind direction.—Here is another source of confusion, one from which force of memory alone can protect us, the naming and charting of wind directions. The weather man's wind vane generally is in the form of an arrow of some sort, and so constructed that the point of the arrow always turns to face the wind. In other words it flies *against* the wind. On his maps and charts, however, he gets all his little wind arrows turned the other way around, for here they fly not against the wind but *with* the wind. What, then, does he mean when he says "north wind," for instance? That is a toss-up until he tells us that he always means a wind from the north. Similarly, by "east wind" he means a wind from the east, by "south wind" a wind from the south, and so on for every point of the compass. It is all simple enough—if you don't forget.

Veering and backing.—Not only the word used to designate the direction of a wind can be confusing, as just explained, but also, and to an even greater extent, those commonly employed to specify the order of its change of direction. Whenever the wind at a particular place so shifts, or changes in direction, as to cause the wind vane to turn clockwise we say that it is veering, and when it so changes as to cause the vane to turn counter clockwise we say it is backing. This, too, is very plain and easy, if only we could remember it—if we could keep from getting like the old lady who said she knew that good eggs sank or swam, but had forgotten which. Indeed it is even worse than that, for while, as used by most writers, backing is backing, and veering is veering, the world over, others reverse the terms with change of hemisphere, calling that shifting of direction veering, in the southern hemisphere, which, in the northern they call backing; and in the southern backing, that which, in the northern, they call veering. Surely the way some words are used is perplexing.

Surface wind is another of the vague terms often used in discussions of the movements of the air. The trouble comes from the uncertainty as to where and what the "surface" is. In the case of calm water there is not much doubt about where the surface is, at least in the every day practical use of the term surface. Over land, however, we usually find a greater and greater entanglement of grass and other vegetation before reaching the soil, and therefore are quite unable to say just where the "surface" is. But in any case where there is a definite surface, as over a lake, for example, the air exactly at the surface we believe to be calm, whatever the wind at appreciable heights above that surface. It would seem then that by the expression "surface wind" we should always mean no wind—no horizontal movement of the air. However, this strictly face value of the expression is not at all what we do mean when we use it. We mean the wind, not at the surface, as the expression implies, but at some appreciable height above it, namely at the level at which the velocity of the air is measured—a level that in practice may be anything from a few feet to twice as many hundred feet above the ground. Clearly then, since the velocity of the wind increases rapidly with increase of height, and since hills and hollows, trees, buildings, and every other irregularity of, and on, the ground affect the velocity of the lower air, the term "surface wind," like the expression "quarter of a lot," has the semblance of meaning something definite but only the semblance.

Fair.—Certainly everyone should know the exact meaning of this term, but many do not and refuse to learn. We may use as vague terms as we like when merely making talk about the weather, but the few terse sentences used by the forecaster certainly should be clearly and correctly understood

by all who read or hear them. Indeed they are clearly understood for they are very carefully constructed to that end, but unfortunately they are by no means always correctly understood. The chief confusion arises from a single one of the forecaster's terms, "fair"—his favorite word (formerly, at least) if one might judge from the frequency of its occurrence. The trouble here comes from the fact that the forecaster and a large portion of his audience, that is, the general public, attach entirely different meanings to this familiar word. He means fair weather; they mean fair skies. To him it is the antonym of foul, and means weather suitable for outdoor occupation; to them it is the antonym of clouds and implies abundant sunshine.

What to do about it is the question. It is precisely the word to use, or certainly would be if rightly understood, but unfortunately there are many who do not know what it means in this connection, and who even are unwilling to learn—who resent being told, who insist that they know what words mean without looking them up in a dictionary or having some smart Aleck tell them. It is too bad, this confusion of meanings, and the worst of it is, there is no obvious and simple way to make the matter any better.

Cyclone.—This is another weather term that often fails to carry the meaning intended. Many people call the "twister" a cyclone, that smallest but most violent, freakish and destructive of all storms. The meteorologist calls this madly whirling devil a tornado, but the man from Missouri, or a neighboring State, comes back with emphasis: "What are you talking about? If my cyclone cellar isn't a place for dodging cyclones, then you will have to show me." This much of the confusion comes mainly from giving the same name, "cyclone," to two entirely different kinds of storms, and two different names, "cyclone" and "tornado," to the same sort of disturbance—the same name to two things, and two names to the same thing.

But this is not all the confusion. If you turn to the word "cyclone" in some large dictionary, or even a meteorological vocabulary prepared by experts, you are likely to find its definition to be: "An area of low atmospheric pressure," or some similar expression. Now, this is inexcusable confusion. A cyclone is not an area at all, any more than a house is an area. It is first and foremost a system of winds, and secondly, characterized by such and such particulars (extensive and about a center of low pressure, accompanied by clouds and widespread precipitation, et cetera) as suffice to distinguish it from all other systems of winds; just as "man" is first of all an animal, and, secondly, possessed of certain qualities, such as rationality, risibility, or whatnot, that belong to no other animal. This is just a fine example of the innumerable cases in which we neither say what we mean nor mean what we say.

Anticyclone.—By its very name one would expect the anticyclone to be something quite the reverse of the cyclone. And so it is in several respects. It occupies a region of relatively high atmospheric pressure, not low, as does the cyclone; its winds, like those of the cyclone, are directed spirally about its center, but outward, not inward, and in the opposite sense; it is attended, usually, by clear skies, not overcast, and fair weather not foul. Meteorologically the cyclone and the anticyclone are distinctly antithetical. Lexicologically, however, they usually have one important feature in common, for generally each is erroneously defined as an area, and not correctly defined as a particular system of winds.

Secondary.—If one were in a teasing frame of mind and wanted some fun with a meteorologist, he hardly could find a better way to succeed than by asking him what a secondary is. He uses this term a lot, and by it he always means a cyclonic storm. Likely as not he will tell you that a secondary cyclone is any one that is not a primary; and that a primary cyclone is any one that is not a secondary. Often, and especially in certain regions, there develops on or near the outer border of a system of cyclonic winds, and doubtless incident to them, a similar system, at first of relatively small extent and strength, but which later grows in size and intensity until, in many cases it itself becomes the main storm, and

occasionally even the only one. This storm, at least in its earlier stages, is often called a secondary cyclone, or secondary, for short, But other storms of less certain history also have been called secondaries for reasons that sometimes seem to be known only to the perpetrator—and he never tells. Yes, ask a meteorologist about secondaries and pretty soon you will have him in a corner, if not up a tree.

Blizzard, a good example of things confused, is a fine word, even if its pedigree is unknown, so long as it means a cold, driving wind filled with blinding snow—a sure-to-goodness storm of the Plains. But how unworthy of itself, how fallen, how decrepit and addled it is when made to mean only a little snow flurry that even a baby scarce would notice. A real blizzard commands respect and deserves a strong name all its own, but the little parlor things that in the Eastern States we so often braggingly call blizzards are not worthy, in comparison, even to be called "blizzetts." A blizzard used to be a blizzard with no doubt about it; now it is anything that has a little snow in it, but one never knows exactly what.

Hail.—Here is a mix-up, too. As used by the U. S. Weather Bureau, and by many people all over the country, only lumps of ice that fall in thunder storms are called hail. Lots of others, though, will not hear of this restriction, but insist that the little ice pellets that fall only in the winter shall also be called hail. That is what they call them, as of course they have a perfect right to do, despite the confusion it causes, and there is no help for it, swear as you may.

Sleet.—Hail is bad enough in its confusion, but sleet is worse, for it has three entirely distinct and much-used meanings. As sung by the poets, and as recorded by the U. S. Weather Bureau, sleet is that which rattles against the windowpane and nothing else. It is frozen raindrops and occurs only in winter and when the temperature of the lower air is below the freezing point while that of the air at around 500 to 1,000 feet elevation is distinctly above it. The rain that falls from the warmer air is frozen by the colder layer below, and reaches the surface in the form of small roundish pellets—ice shot. This is sleet, according to one definition and extensive usage. According to British usage, though, and the custom of many in America also, sleet is a mixture of rain and snow. They call the frozen raindrops hail, or winter hail. This is confusion enough, but by no means the whole of it, for the engineer, ignoring both the above definitions, restricts the name sleet to the smoothish coats of ice that sometimes form on wires, street-car rails and other exposed objects. This sleet, in the engineer's sense of the term, the U. S. Weather Bureau calls glaze. It is the characteristic feature of an ice storm.

And nothing can be done about it. Even if we could get the engineer to call glaze (an excellent word) that which he now calls sleet and restrict this term, as so many of us do, to the stuff that rattles, there still would remain the mixture of snow and rain to rechristen. Of course, a word-telescoping genius like Lewis Carroll might call it "snane," but then some one would be sure to laugh at it, if he did not even make a face.

Ice-flower.—If sleet is a vague term owing to its three definitions, what shall we say about "ice-flower" that means any one of five distinct things? Two or three generations ago Tyndall tried the happy experiment of putting a sheet of ice in the usual position of a lantern slide, and was rejoiced to see blossom on the screen a beautiful bed of six petaled flowers—images of course, of internal melted ice crystals. These 6-rayed cavities Tyndall, in his poetic way, and very appropriately, called ice-flowers. Pretty soon some one else, also with a poetic fancy, gave the same name to the beautiful fernlike figures Jack Frost traces on your windowpane. Then some nature lover, enthusiastically describing the tufts of frost that sometimes in bitterly cold weather grow up numerously on a sheet of ice, called them also "ice-flowers." Even the little columns of ice that spring up from damp soil, and resemble in a measure the familiar Indian pipe, have been called ice-flowers. Finally, at least finally up to the present, the exquisite, curling and satiny ice ribbons, as thin and broad as the blade of a case knife, and often fully as long, that in early winter grow out from the dead stems of rock mint, likewise have been called ice-flowers.

And no wonder, for among the brown leaves of the woods these ice formations look for all the world like a field of beautiful white lilies.

In every one of these five cases the name ice-flowers seems appropriate, yet its use for more than one, preferably the first, is to be deprecated, for it leads only to confusion.

Climate.—It is a long call in one sense from ice-flowers to climate, but the terms have one bad feature, muddle meaning, in common. Perhaps climate is most often defined as "average weather." That would seem to justify defining weather as irregular climate. However, both these snap definitions are hopelessly inadequate. The average annual temperature of a place, average rainfall, and average all-the-other-things do not tell the story of its climate. We need for this purpose to know also the extremes, frequencies of such and such values, normal run of the weather elements through the year, and a lot of other matters as well. In short, the climate of a place is neither its average weather nor the average of its weather, but the history of its past weather.

Drought.—This much used term also is a term confused. Most of us use it glibly as though we knew exactly what it meant until, perchance, we need to define it precisely whereupon our concept of it begins to fade away. We ask ourselves whether it is a number of consecutive days without rain or snow, and, if so, how many. Then we wonder whether the amount of the immediately preceding precipitation should be considered in our definition, and whether the time of the year matters. And if we take a certain number of consecutive days without rain as our definition of drought for one region will that also hold for every other region? Would such a drought for New England be also a drought for New Mexico? If not, then what is a drought? Most of us will agree that one one-hundredth of an inch of rain will not break a drought, and if it will not then certainly we can not define a drought as so many consecutive days without any rain at all, though sometimes, and for statistical purposes, such a rainless spell has been called an absolute drought. Perhaps we might better define a drought as so many consecutive days without more than a specified small amount of rain. But this does not avoid the difficulties as to season and place.

Really, drought is a hard term to deal with. Possibly the best thing to do whenever accuracy is essential is to give it an arbitrary, but reasonably exact, definition appropriate to the needs of the occasion.

Spring.—Who knows when spring begins, or any of the other seasons, for that matter? If we take Tennyson's dictum that it is "when a young man's fancy turns to thoughts of love," we must conclude that it is a perpetual season! If, on the other hand, we take the word at its primitive meaning, signifying the season when plants spring up, we will be forced to conclude that the beginning of spring varies from place to place and year to year, and also that it depends on the kind of plant selected as the criterion. We will even conclude that it has no beginning in ice covered regions, and that it goes on forever in tropical lands.

This indefiniteness led to the more or less general adoption of fixed dates for the beginning and end of each season. In so doing the spice of life was amply preserved for surely in the dates of these beginnings there is abundant variety. According to popular English usage spring begins with the first of February. In America we put it a month later, first of March. Astronomers, though, say it begins with the vernal equinox, which may be at any instant through the day, usually, but not always, on the twenty-first of March, and lasts until the coming summer solstice, also a slightly variable date. Here are three widely used but distinctly different dates for the beginning of spring. February 1, March 1, and March 21 or 22, spread over a period of seven weeks. And so it is with the other seasons, for they follow each other at approximately equal intervals of time. Clearly, then, "first day of spring," "last day of summer," and all others of their kind are confusing expressions for to equally well informed people they convey the concept of distinctly different dates.

End of twilight.—When the end of twilight comes is another point about which the astronomer and the general public have occasion to differ, though confusion in this

case is not nearly so bad as it is in regard to the beginning of spring. The astronomer who, for most of his work, prefers the clearest skies and the darkest hours, says twilight ends only with the last trace of scattered sunlight in the western heavens. On clear nights, the only kind in which he is interested, this last glimmer disappears when the center of the sun is about 18 degrees below the horizon. This does not suit the average person who considers twilight to end as soon as it gets too dark for people to go about their ordinary outdoor occupations. On clear evenings this occurs when the center of the sun is about 6° below the horizon, or in about one-third the time from sundown to the end of astronomical twilight. On cloudy evenings twilight, in this work-a-day sense, ends much sooner, but there is no fixed time for it—the term is vague and often confusing.

Light and dark of the moon.—Whoever follows the foolish occupation of moonfarming, of planting things that fruit above the ground in the light of the moon, and tubers that grow under the soil in the dark of the moon, is confronted with the puzzling necessity of knowing just when it is light of the moon and when dark. And the more he tries to be certain of the matter the more confused he is likely to become. Some will tell him that dark of the moon is that brief time, three or four days, before new moon when it is not seen at all owing to its nearness to the sun, and light of the moon the three or four days centered about full moon. Others, while agreeing with this definition of dark of the moon, will insist that all the rest of the time is light of the moon. Still others, with equal assurance, will insist that the time the moon is waxing, that is, the time of the first and second quarters, is light of the moon, and that the time of its waning, the duration of the third and fourth quarters, is dark of the moon. Finally, there are many who recognize light of the moon to be all the days when the moon is above the horizon most of the fore part of the night, and all the rest of the time dark of the moon.

Here are three distinct and widely recognized definitions of dark of the moon, and four of the light of the moon. What then can the poor moon farmer do when up against such conflicting definitions as these? Nobody knows, though it is quite certain what he should do—forget the moon foolishness and plant when the ground is ready and the season right, as all sensible farmers do.

And these listed above are not the only weather words loosely used by the general public, whose omnibus excuse is the fact that, if restricted to correct understanding and clear expression, the pleasant glibness of its tongue would be lost in many a dreary silence—an honest enough excuse but a mighty poor one.

PALEONTOLOGY.—*An interesting occurrence of fossil tracks in West Virginia.*[1]

David H. Dunkle, U. S. National Museum. (Communicated by C. L. Gazin.)

Recently, through the generosity of Harold T. Stowell, of Westmoreland Hills, Md., the U. S. National Museum received a small slab of rock exhibiting two distinctly impressed tracks. The following brief report on the specimen is prompted by the probable tetrapod nature of the prints and by the geologic details of its occurrence.

The prints are impressed upon the upper undulating surface of a thin block of dense, finely grained sandstone, composed of many small cross-bedded laminae of variegated red and buff color. As found by Mr. Stowell in 1939, the slab lay loose at the base of a cliff on the East Bank of the Greenbrier River, about 1 mile south of the mouth of Island Lick Run, in the Watoga State Park, Pocahontas County, W. Va.

The physical expression of fossil trackways is dependent on a number of variable conditions. Seldom are the remains of the causative agent found associated with the prints. The structure of the contributing organ, therefore, must be inferred. This latter is very often difficult because the

[1] Published by permission of the Secretary of the Smithsonian Institution. Received December 5, 1947.

completeness of the impression is subject, at the time the tracks were made, to the composition and the consistency of the substratum and, subsequently, to all the multiple, special factors for their preservation. The interpretation of the present examples is not exempted from these general difficulties.

The two tracks, oriented parallel to each other, are each composed of the depressions made by three, stout, distally tapering digits. When the block is placed with the divergent extremities of the impressions directed away from the observer (Fig. 1), it may be seen that the track on the left is more deeply impressed and is situated slightly above the one on the right.

From the similar lengths and practically identical angles of divergence of the corresponding digital impressions in each of the two tracks, it is conceivable that the prints could have been made by one and the same appendage of an animal crossing the photograph transversely. In this latter event, however, the limb would seem necessarily to have extended out at a right angle to the longitudinal axis of the body with little or no anterior flexure. The literature on fossil trackways fails to reveal the occurrence of such a structural condition in the Late Paleozoic. Further in opposition to such an interpretation is the fact that the distance between the two prints would represent an extremely short stride, especially when the slab is large enough transversely to exhibit both preceding and succeeding impressions.

During the tetrapod propulsive cycle (Schaeffer, 1941; Evans, 1946), the body weight, first distributed over the entire surface of either the hand or foot, progressively

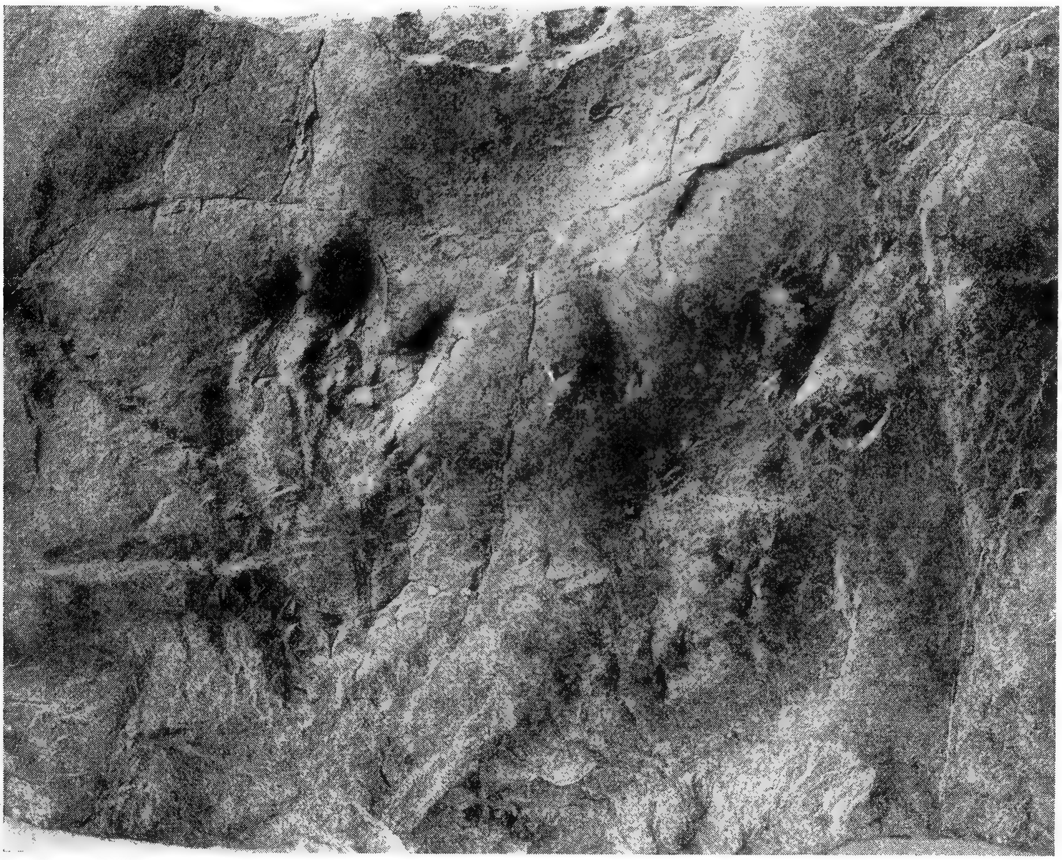

Fig. 1.—Photograph of fossil tracks (U.S.N.M. no. 17656) obtained in the Watoga State Park, Pocahontas County, W. Va. Reproduction approx. ×3/5.

shifts to a final concentration on the medial digits. While variable (Colbert and Schaeffer, 1947), this action ideally results in a deeper impression of the inner side of the organ than any other of its parts. The sides of the present fossil footprints, which are adjacent to each other, are clearly more deeply impressed than their distant sides. Thus, while the evidences are conflicting, it is here assumed that these tracks were made by a limb and its complement from the opposite side. Whether that pair of appendages was anterior or posterior can not be ascertained.

Markings of the pads of either heel or palm are not discernible. Impression of the digits alone indicates that the tracks were made on a fairly firm substratum. As pointed out by Colbert and Schaeffer (1947), the lateral digits are structurally the most divergent and under the least optimum of conditions are the most poorly defined in trackways. Thus, while 3-toed impressions have been encountered in practically every known geologic occurrence of tetrapod tracks, it remains uncertain whether complete impressions are being dealt with in the present case. No attempt here is made to assign these prints to any of the scientific names available because of the above mentioned uncertainties of interpretation and because of the questionable advisability of such practice. The specimen is no less interesting for this failure, however, because an early and unknown animal of considerable dimensions is indicated. The better preserved left imprint measures roughly 35 mm across the proximal base of the digits. The distance between parallel lines projected through the medial borders of the prints approaches 62 mm.

The block of sandstone bearing the impressions may be assumed to have been derived at or very near the site of its discovery. No evidences of transportation can be observed. The edges of the slab remain sharply angular. Fragments of soft red shale still adhere in the concavities on both its upper and lower surfaces. Furthermore, its lithology is identical with that of the bedrock exposed in the immediate vicinity as well as for many miles upstream. Price (1929) identifies this rock as the Pocono formation. As summarized by Branson (1910) and Colbert and Schaeffer (1947), the oldest previous reports of definitive tetrapod tracks in the United States are restricted to the upper Mississippian Chester Series. The literature (Butts, 1940; Chadwick, 1935; Willard, 1936) suggests a transgressive character to the Pocono sediments and a consequent variation in age from place to place. Notwithstanding, the Pocono is well below the Chester equivalent, the Mauch Chunk, in the West Virginia section. The present occurrence, therefore, seems to be the earliest yet known from our country and approaches in age the oldest authenticated tetrapod tracks from the Horton Series of Nova Scotia (Dawson, 1894; Sternberg, 1933).

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MYCOLOGY.—*The swarm-cells of Myxomycetes.*[1] EUGENE W. ELLIOTT, State University of Iowa. (Communicated by G. W. MARTIN.)

Biflagellate swarm-cells have been observed as occurring occasionally in Myxomycetes by many observers, but it has been generally held that the swarm-cells in this group are normally uniflagellate. DeBary (*1*) in 1884 and Vouk (*20*) in 1911 reported biflagellate forms in exceptional cases only. Gilbert (*6*) found one-fourth of the swarm-cells of *Stemonitis fusca* biflagellate. Von Stosch (*19*) saw biflagellate cells in many other species, but none in the single species of *Stemonitis* that he studied. Gilbert (*7*) reported *Dictydiaethalium plumbeum* to be uniflagellate, but E. C. Smith (*17, 18*) twice within the following year published photomicrographs showing biflagellate swarm-cells in the same species. Howard (*10*) termed biflagellate swarm-cells in *Physarum polycephalum* "common." Sinoto and Yuasa (*16*) studied *Ceratiomyxa* and four species of Myxogastres, finding only one flagellum in *Ceratiomyxa* but occasional bi- and even triflagellate forms in all the others. Yuasa (*21*) likewise found bi- and triflagellate cells in *Fuligo septica.* Jahn (*11*) in 1928 ignored the previous reports of biflagellate swarm-cells; and in 1936 (*12*) he criticized the work of Von Stosch, insisting that swarm-cells are normally uniflagellate and that all biflagellate swarm-cells are anomalies. Karling (*13*) in his general summary of the literature pertinent to the relationships between the Plasmodiophorales and the Myxomycetes, says that "although the majority are uniflagellate, zoospores with two flagella are not uncommon. . . ." In 1945 Ellison (*5*) reported biflagellate swarm-cells in proportions varying from 2 to 26 percent for a number of species of Myxomycetes but retained the assumption that the majority are uniflagellate.

It is not inconceivable that an occasional biflagellate swarm-cell could occur as an abnormality in an otherwise uniflagellate group. But biflagellation has already been reported too frequently in the Myxomycetes to represent mere abnormality. And on the basis of flagellation as reported in other groups it is very unlikely that both uniflagellate and biflagellate forms would normally exist in the same life stage of the Myxomycetes. It seems more probable that the second, shorter flagellum is difficult to see and is frequently hidden. This study was undertaken to determine whether this latter assumption is not the case.

[1] Received December 15, 1947.

METHODS AND MATERIALS

Spores of 21 collections representing 11 species were germinated for these tests. Following is a list of the collections, with the State and year of collection:

1.	*Arcyria denudata*	Iowa	1947
2.	*Dictydiaethalium plumbeum*	Iowa	1947
3.	*Dictydiaethalium plumbeum*	Iowa	1947
4.	*Enteridium rozeanum*	Iowa	1946
5.	*Enteridium rozeanum*	Iowa	1946
6.	*Enteridium rozeanum*	Iowa	1947
7.	*Fuligo septica*	Indiana	1944
8.	*Fuligo septica*	Michigan	1947
9.	*Lycogala epidendrum*	Indiana	1944
10.	*Lycogala epidendrum*	Iowa	1946
11.	*Lycogala epidendrum*	Iowa	1947
12.	*Oligonema schweinitzii*	Iowa	1947
13.	*Oligonema schweinitzii*	Iowa	1947
14.	*Physarum polycephalum*	Iowa	1947
15.	*Reticularia lycoperdon*	Iowa	1929
16.	*Reticularia lycoperdon*	Iowa	1942
17.	*Reticularia lycoperdon*	New York	1947
18.	*Reticularia lycoperdon*	Iowa	1947
19.	*Stemonitis flavogenita*	West Virginia	1947
20.	*Stemonitis splendens*	Iowa	1947
21.	*Trichia affinis*	Iowa	1946

The first cultures were prepared in September 1946, using *Reticularia lycoperdon* (Coll. no. 15, above), *Lycogala epidendrum* (no. 10), and *Trichia affinis* (no. 21). Abundant germination was obtained in the first attempts with *R. lycoperdon* and *T. affinis,* but only one of several cultures of *L. epidendrum* was observed to germinate. Repeated attempts to germinate cultures of the two oldest collections of *Enteridium rozeanum* (nos. 4 and 5) resulted in the observation of occasional swarm-cells in no. 4, but only very low percentages of germination. Other species gave similar results.

Cultures were made in Syracuse watch glasses using distilled water from which the traces of toxic minerals were removed with powdered charcoal. It was observed fre-

quently that most of the spores placed in the culture dish continued to float on the surface of the water, never becoming wet. This was especially true of those forms having very small spores, such as *Enteridium* and *Lycogala*. Various wetting agents were tried in an attempt to accelerate the wetting and increase the germination of these spores.

Alcohol was the first wetting agent tested. Cayley(*4*) used 20 percent alcohol for wetting spores of *Didymium* sp., securing approximately 50 percent germination whether the spores were in the alcohol "a few minutes" or a full hour. Also she used a solution of 0.2 percent mercuric chloride in a mixture of equal parts of 95 percent alcohol and water, as a combined wetting agent and bactericide. The resulting cultures were not bacteria-free and germination was poor.

In the tests here reported a number of different dilutions of alcohol were tried, 95 percent being the strongest and 20 percent the weakest concentration used. Lower concentrations had negligible wetting effect. After wetting, spores were washed three times with centrifuging and cultured as before. No germination was obtained from spores wetted with alcohol, even in *Reticularia lycoperdon*, in which nearly 100 percent germination had been secured without the use of a wetting agent.

Trisodium phosphate was tried next. By experimentation it was found that spores of *Enteridium rozeanum*, which has the smallest spores of any species used up to the time of these tests, would sink immediately in a 0.5 percent solution and slowly in a 0.2 percent solution. In preparing cultures using trisodium phosphate as a detergent, washing was done as when alcohol was the wetting agent. Cultures of *E. rozeanum* (no. 5), prepared with the use of trisodium phosphate in either 0.5 percent or 0.2 percent solution, germinated nearly 100 percent within one hour. Swarm-cells had not been seen in cultures of this collection before.

Trisodium phosphate in 0.5 percent solution was used as a detergent in preparation of cultures of a number of other collections. Abundant germination was produced occasionally in *Lycogala epidendrum* (no. 10), but no consistent germination was secured with any species except *E. rozeanum*, hence toxic effects were suspected.

In the search for an active detergent without toxic effects, two commercial detergents, "Soilax" and "Dreft," were tried, both in 0.5 percent solution. Both acted as effective wetting agents, but many spores were caught in the foam on the "Dreft" solution and could not be reclaimed by centrifuging. Germination in cultures thus prepared was similar to, and no more satisfactory than, that obtained with trisodium phosphate.

The fact that bile salts greatly lower the surface tension of solutions, as exemplified in the Hay test for bile in urine (*9*), inspired the testing of solutions of sodium glycocholate and sodium taurocholate as wetting agents for preparation of cultures. It was found that either the glycocholate or the taurocholate will wet the spores satisfactorily in 1 percent solution, but lower concentrations act so slowly as to be inadequate. In equal concentrations, these two salts, or a mixture of them, are equally effective as wetting agents.

Spores of many species of Myxomycetes that did not germinate at all when prepared directly in water or with other detergents, germinated when previously wetted with either of the bile salts. And all those collections which germinated directly in water germinated more quickly and in greater percentage when previously wetted with the bile salts. Of course, the spores of two different collections of the same species frequently show greatly different percentages of germination. Similar differences are apparent when the bile salts are used, other conditions being equal; but the differences are substantially reduced.

Germination of spores directly in 1 percent solution of the bile salts was tried. Protoplasts emerged from the spore cases, but developed no further. However, a technique was developed in which only one washing with water is necessary to free wetted spores of the detergent. Approximately 1 cc of the wetting agent is placed in a centrifuge tube and the spores to be cultured are added and stirred until wetted, a process which usually takes one-half minute. Then the solution is diluted to 5 or 6 cc with water and promptly centrifuged. The spores are then washed once with distilled water by centrifuging and are finally cultured in

distilled water prepared with charcoal as described above.

It was found that in order to preserve the flagella of swarm-cells for observation, the killing agent used in preparation of material for microscopic examination must act very quickly. Smears prepared by air-drying, or even by drying as quickly as possible over mild heat, as is done in the preparation of bacterial mounts, showed recognizable swarm-cells, all of which, however, completely lacked flagella.

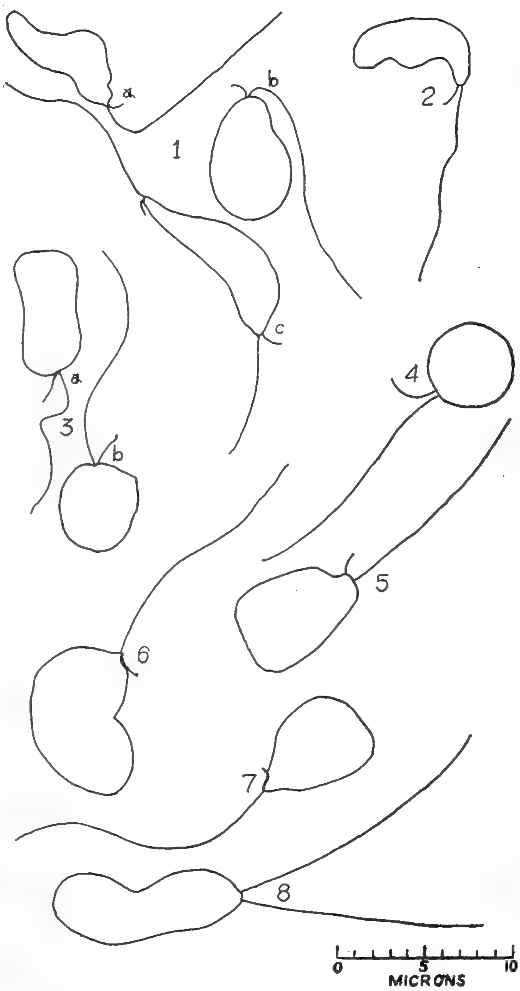
The most satisfactory results for temporary mounts were obtained by killing and staining on the slide with a drop of iodine-potassium iodide solution. For this purpose Gram's iodine is used without dilution, density of staining being controlled by varying the proportions of culture solution and iodine solution which are mixed on the slide. Whatever proportions are used, mixing must be accomplished quickly and thoroughly if the flagella are to be preserved for observation.

Permanent slides were prepared for observation of flagella by use of a modification of the Loeffler stain for bacterial flagella (*3*). The mordant and stain were prepared as directed, but the times of application of both mordant and stain were reduced from five minutes to one-half minute. Smears were prepared by various means. Slides were thinly coated with albumin fixative, on which a drop of culture solution was placed and inverted over osmic acid fumes. This was then allowed to dry in air. Other smears, killed over osmic acid, were fixed by heating gently after drying. Still others were killed with iodine, as was done in the preparation of temporary mounts, and allowed to stand until the iodine had sublimed. These slides were fixed over heat. The crystals of potassium iodide were dissolved off in distilled water before staining. Equally satisfactory results were obtained with all these methods. The iodine method, being the simplest, was used.

RESULTS AND DISCUSSION

Some biflagellate swarm-cells were observed in every culture prepared of every species studied. In some species, notably *Lycogala epidendrum, Oligonema schweinitzii,* and *Fuligo septica,* the proportion of swarm-cells obviously biflagellate was nearly 100 percent. In one culture of *Dictydiaethalium plumbeum,* many zygotes with four flagella, in two pairs of two each, were found.

In all species except *Stemonitis splendens,* the two flagella were of greatly different length, the shorter one being sometimes scarcely more than 1μ long. The length of the shorter flagellum is quite constant for a given species. The flagella of *Stemonitis splendens* averaged 16μ for the longer flagel-



FIGS. 1–8.—Outlines of representative swarm-cells: 1, *Dictydiaethalium plumbeum* (*a–b*, swarm-cells; *c*, zygote) (all others are swarm-cells); 2, *Enteridium rozeanum;* 3, *a–b*, *Fuligo septica;* 4, *Lycogala epidendrum;* 5, *Oligonema schweinitzii;* 6, *Physarum polycephalum;* 7, *Reticularia lycoperdon;* 8, *Stemonitis splendens.*

lum and 14μ for the shorter. Ellison drew swarm-cells of *Stemonitis fusca* and *S. ferruginea* with two flagella approximately equal in length, though the other biflagellate forms he records have one flagellum much shorter than the other. Similarly, Gilbert (*6*) shows *S. fusca* with two nearly equal flagella, but all other forms definitely heterocont.

The second flagellum, in addition to being very short, is usually recurved so as to be almost indistinguishable from the outline of the cell itself. Even in *Stemonitis splendens*, in which both flagella are relatively long, one is usually trailing, so that it is easily overlooked. The significance of this point is borne out in the following observation: A temporary mount was prepared from a culture of swarm cells of *Dictydiaethalium plumbeum*. The mount was killed and stained with Gram's iodine. Using the 90X oil immersion objective, the microscope was focused upon a swarm-cell in which both flagella were easily seen. Then, by touching the edge of the cover slip with a dissecting needle, the mount was disturbed while the original swarm-cell was kept in view. This swarm-cell was observed to roll over and again come to rest. In its new position, the shorter flagellum could not be seen with any manipulation of the microscope. A second swarm-cell which presented only the longer flagellum to view was found, and by simularly disturbing the cover slip the swarm-cell was maneuvered until the shorter flagellum could also be seen. This same demonstration of the fact that the shorter flagellum may be—and frequently is—hidden by the body of the cell, was also performed on mounts of *Fuligo septica* and *Arcyria denudata*.

The second flagellum is clearly visible on only a very few swarm-cells in most mounts. Some mounts stained with Loeffler's technique were destained to transparency with acid alcohol. On swarm-cells thus prepared the flagella remained clearly stained, but the body of the cell was sufficiently destained so that the nucleus and other cellular details were visible. When swarm-cells are properly stained by this method, careful focusing on the anterior portion of the body of the cell will reveal a dark line reaching backward from the apex to the base of the conical anterior portion. Occasionally this dark line will be found lying across the conical portion, either on or underneath the body of the cell, but most frequently it is barely distinguishable from the outline of the cell. It is not found on those swarm-cells on which the second flagellum is clearly visible apart from the body of the cell. It is believed that this is the shorter flagellum which ordinarily is closely appressed to the anterior portion of the cell.

CONCLUSIONS

Spores of 21 collections representing 11 species of Myxomycetes were germinated. The flagellation of the swarm-cells of these species was observed in temporary and permanent preparations. In three species, *Fuligo septica*, *Lycogala epidendrum*, and *Oligonema schweinitzii*, it was possible to see two flagella on nearly every swarm-cell observed. In all other species, two flagella were clearly visible on some swarm-cells, and it was demonstrated by manipulation of fluid mounts that the second flagellum could be brought into view even though not originally visible. From this it is inferred that if adequate technique were used, the second flagellum would be found on all myxomycete swarm-cells.

All of the biflagellate swarm-cells observed in this study were heterocont. In all species except *Stemonitis splendens* the two flagella differ greatly in length. In *S. splendens* the difference is slight, but is nevertheless constant.

The Myxomycetes and the Plasmodiophorales have long been considered related groups by may investigators. Formerly, the reported existence of anteriorly uniflagellate zoospores in the reproductive cycle of both groups was regarded as strong evidence of this relationship. However, Ledingham (*14, 15*) showed that the zoospores of the Plasmodiophorales are anteriorly biflagellate, the second flagellum being very short and, hence, easily obscured. As a result of Ledingham's finding, the supposed difference in flagellation was thought by many to emphasize a separation between the two groups.

The existence of two blepharoplasts has been reported in several species of Myxomy-

cetes (*5, 8, 19*). Bessey (*2*) regards the second blepharoplast as a vestige of the biflagellate condition, indicating that the Myxomycetes and the Plasmodiophorales have arisen from a common ancestor. He considers the loss of the second flagellum as evidence that the Myxomycetes are of higher phylogenetic position.

Insofar as flagellation is of phylogenetic significance, the existence of the second flagellum in the swarm-cells of Myxomycetes as demonstrated by this study, may indicate a closer relationship with the Plasmodiophorales than has recently been supposed.

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ORNITHOLOGY.—*A small collection of birds from Eritrea.*[1] HERBERT FRIEDMANN, U. S. National Museum.

During the early stages of World War II when North Africa was an important battlefield, numbers of American troops were stationed in Eritrea, a rather neglected and little-known part of eastern Africa. Two of the men who were destined to spend some time in that former Italian colony collected birds as time and opportunity permitted. Col. L. R. Wolfe sent in to the U. S. National Museum a small box containing eight birds. A second and larger shipment comprising about 300 specimens was most unfortunately lost in transit. Thane Riney similarly suffered the loss of the bulk of his collection, but was able to bring back some 37 birds, which he forwarded to the Museum of Vertebrate Zoology of the Univer-

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sity of California, where most of them are now. A small number, chiefly duplicates, were generously presented by that institution to the National Museum, where they together with Wolfe's handful of specimens, are incorporated with the large East African material previously brought together by Mearns and others.

Because of the paucity of published data concerning Eritrean birds I thought it advisable to put on record the contents of the Wolfe and Riney collections, small though they be, and, thanks to the cooperation of Dr. Alden H. Miller and Dr. Frank A. Pitelka, I have been able to examine all the specimens and to combine them in this report. A collection containing only 34 species could hardly be expected to yield many new facts, but as may be seen from the subjoined annotated list, a few items of interest have been found to be contained in it.

Family Accipitridae: Hawks, Eagles, and Kites

Elanus coeruleus coeruleus (Desfontains)

Falco coeruleus Desfontains, Hist. (i.e., Mém.) Acad. Roy. Paris, for 1787: 503. 1789 (near Algiers).

One specimen, in somewhat abraded plumage, was collected at Ghinda, altitude 962 meters, on February 2, 1943, by Thane Riney.

Melierax metabates metabates Heuglin

Melierax metabates Heuglin, Ibis 1861: 78 (White Nile between 6° and 7° lat. N.).

During August (16–26), 1942, Wolfe collected an adult male, adult female, and a juvenal male 15–20 miles south of Gura. Riney obtained an adult (unsexed) between Cheren and Agordat, on December 12, 1942. The very extensive white freckling on the secondaries and inner primaries of the adults suggests that they may be somewhat intermediate between *neumanni* and true *metabates*, but nearer to the latter. They have the barred upper tail coverts of the nominate race.

Sclater and Mackworth Praed (Ibis 1919: 702) consider all Sudanese birds south of Khartoum and north of Lake No as intermediate between the two races. Moltoni and Rusconi (Gli Uccelli dell' Africa Orientale Italiana **2**: 240. 1942) record *neumanni* from Eritrea near the border of the Red Sea Province of the Sudan, and *metabates* from the rest of Eritrea.

The birds are rather small, the adult male having a wing length of 300, the female of 307 mm. In this respect they approach the southwest Arabian race *ignoscens*.

The August birds show evidences of molting.

The juvenal female is slightly more rufescent on the breast and darker on the upperparts than comparable birds from extreme northwestern Uganda.

Buteo rofofuscus augur (Rüppell)

Falco (*Buteo*) *augur* Rüppell, Neue Wirbelth., Vög.: 38, pl. 16. 1836 (Abyssinia).

A female was taken by Riney about 20 km from Decamera, on January 1, 1943, at an elevation of 2,000 meters. A second specimen is unfortunately without data of any kind. Both are in the light phase.

Lophaetus occipitalis (Daudin)

Falco occipitalis Daudin, Traité **2**: 40. 1800 (the Anteniquoi country, i.e., Knysna district, Cape Province).

Wolfe collected a male and an unsexed bird, both adults, 15–20 miles south of Gura, August 16, 1942. He found the crested eagle not uncommon at elevations of about 5,000 feet.

Aquila rapax raptor Brehm

Aquila raptor Brehm, Naumannia 1855: 13 (Blue and White Nile).

An adult female in worn plumage was taken by Riney on a nest in a baobab tree, south of Barentu, January 17, 1943. The date is in agreement with Blanford's observation (Geol. and Zool. Abyss.: 295–296. 1870) that in Ethiopia the birds breed in January.

Circus pygargus (Linnaeus)

Falco pygargus Linnaeus, Syst. Nat., ed. 10, **1**: 89. 1758 (Europe).

Riney collected an unsexed bird (female by plumage) 5 km west of Asmara at an elevation of 2,409 meters, on January 4, 1943, when he saw it foraging over open fields. The bird is in rather poor plumage and is molting its remiges, making definite identification somewhat difficult. The third primary, from the outside, is only partly grown in, while the remainder of the remiges is considerably abraded.

Montagu's harrier is a Palearctic bird and

comes into Africa only during the northern winter. In eastern Africa it has been recorded all the way to South Africa.

Family FALCONIDAE: Falcons

Falco naumanni pekinensis Swinhoe

Falco cenchris var. *pekinensis* Swinhoe, Proc. Zool. Soc. London 1870: 442 (Shihshanling (Ming Tombs) near Peking).

An adult male, taken near Asmara, 2,371 meters, on January 31, 1943, by Thane Riney, is in somewhat worn plumage and differs from the nominate race in its darker rufescent back. Archer and Godman (Birds of British Somaliland and the Gulf of Aden **1**: 180–183. 1937.) consider this race a rare straggler to their area and suggest that it may follow down the Nile Valley to the west. If we were to apply this suggestion to Eritrea we should have to consider the bird a rare visitor to that country as well, which actually seems to be the case; in fact, Riney's specimen is the first record for Eritrea, at least as far as published data indicate. The bird is known to reach South Africa during the northern winter and is probably commoner along the eastern part of the continent than the few records would indicate.

Falco alopex (Heuglin)

Tinnunculus alopex Heuglin, Ibis 1861: 69, pl. 3 (Gallabat, Egyptian Sudan).

A male, collected by Wolfe, 15 miles south of Gura, August 16, 1942, is noticeably darker than a female from Talodi, Kordofan, Anglo-Egyptian Sudan, the only other example of the species available for comparison. Our male also differs from this female in having the black bars on the median rectrices more complete, less marginal in character, and in having those on the lateral rectrices less broadened. There is a tendency in the female to have these bars dilated marginally on all the tail feathers, but this is most highly developed on the outer ones.

Bannerman (Birds Tropical West Africa **1**: 216–219. 1930) has given more extensive comments on this species than any other recent writer. He states that the wing measurement of the males varies from 266 to 293 (our example measures 276 mm). His account is unfortunately garbled by some misprinting of his original intention as he then goes on to state that the "largest birds are those from N. Nigeria with wings ♂ 212 ♀ 210. . . ."

The intensity (darkness or paleness) of the coloration appears to vary individually in this kestrel. Bannerman had 23 specimens for study and found the darkest birds came from such widely separated areas as Kulikoro on the Niger River, Jebel Marra in Darfur Province, Anglo-Egyptian Sudan, and Ethiopia. On the basis of this spotty occurrence of dark birds (among which the present Eritrean example appears to belong) it seems impracticable to recognize Oberholser's race *eremica* from Togoland, which is based entirely on its paler tone. Bannerman (*loc. cit.*) has placed *eremica* in the synonymy of *alopex*, but, probably by oversight, he uses a trinomial for the latter.

Our specimen shows signs of molt in the remiges and rectrices. This suggests the possibility that its darker tone may be due to the freshness of its plumage and that paler birds may show the results of fading under the hot sun in the dry open country it inhabits.

Falco tinnunculus tinnunculus Linnaeus

Falco tinnunculus Linnaeus, Syst. Nat., ed. 10, **1**: 90. 1758, (Europe; restricted type locality, Sweden *apud* Hartert).

Riney shot a female 10 km from Decamera, at 2,050 meters, on January 1, 1943. The bird has a wing length of 258 mm and is therefore too large to be *F. t. archeri* Hartert and Neumann from the Waghar Mountains, and also too large to be *F. t. carlo* (Hartert and Neumann) of the mountains of East Africa. In coloration it is slightly darker than typical *tinnunculus* but not as dark as *carlo*. It seems best treated as a darkish example of the nominate race.

Family PHASIANIDAE: Pheasants, Francolins, and Quails

Francolinus erckelii erckelii (Rüppell)

Perdix erckelii Rüppell, Neue Wirbelth. Vög.: 12, pl. 6. 1835 (Taranta Mountains, Abyssinia).

Erckel's francolin is a poorly known bird, and any additional material of it is still of interest. Riney collected a female, 40 km north of Asmara, 2,390 meters altitude, on January 9, 1943. It is smaller than any mentioned by Moltoni and Rusconi (Gli Uccelli dell' Africa Orientale Italiana **3**: 22–25. 1944.) having a wing length of only 202.6 (their series ranges from 205 to 230), and a tail length of 91 (as against 110–140 mm in Moltoni's series).

Moltoni and Rusconi write that the race *pentoni* ranges from the Red Sea Province of the Sudan into the adjacent parts of Eritrea, but as far as I can learn no actual specimens of this paler, grayer race have been taken in Eritrea.

Family COLUMBIDAE: Pigeons and Doves

Oena capensis capensis (Linnaeus)

Columba capensis Linnaeus, Syst. Nat., ed. 12, **1**: 286. 1766. (Cape of Good Hope).

Riney collected a male in low bush near the Decamera turn off on the Adi-Ugri Road, 45 km south-southwest of Asmara, on January 1, 1943. The bird is in abraded plumage.

Family APODIDAE: Swifts

Apus aequatorialis aequatorialis (Müller)

Cypselus aequatorialis Müller, Naumannia **1**: 27. 1851 (Abyssinia).

A female mottled swift was taken by Riney on the Citao compound at Asmara on February 2, 1943. It is a bird in rather worn feathering.

Family COLIIDAE: Colies, or Mousebirds

Colius striatus leucotis Rüppell

Colius leucotis Rüppell, Mus. Senck. **3**: 42, pl. 2. 1839 (Temben Province, Abyssinia).

Two unsexed examples of this common species were obtained by Riney, one on the Adi-Ugri Road at the base of the Asmara Plateau, on November 14, 1942, and one near Cheren, on March 15, 1943. This race inhabits Eritrea, Bogosland, northern Ethiopia, and adjacent portions of the Anglo-Egyptian Sudan.

Family CORACIIDAE: Rollers

Coracias naevius naevius Daudin

Coracias naevia Daudin, Traité **2**: 258. 1800 (Senegal).

Wolfe obtained one specimen, unsexed, south of Gura, on July 26, 1942. It has the white stripes on the anterior underparts unusually broad and has the purplish brown of the top of the head and the greenish of the back slightly darker than in Ethiopian specimens. It has an unusually large bill, the culmen measuring 47 mm from the base; the largest billed birds from Ethiopia and Kenya Colony seen having culmen lengths of 43 mm or less. The specimen was molting when collected, the outer remiges still showing their sheaths basally.

Family UPUPIDAE: Hoopoes

Upupa epops somaliensis Salvin

Upupa somaliensis Salvin, Cat. Birds Brit. Mus. **16**: 13. 1902 (Somaliland).

On February 2, 1943, Riney obtained an adult female on the acacia plain between Nefasit and Decamara, altitude 1,825 meters. It matches Ethiopian and East Africa examples very well. This is the resident race, the nominate one being only a winter visitor from Europe.

Family BUCEROTIDAE: Hornbills

Tockus nasutus nasutus (Linnaeus)

Buceros nasutus Linnaeus, Syst. Nat., ed. 12, **1**: 154. 1766 (Senegal).

The gray hornbill is represented by a head collected south of Gura, in August 1942, by Colonel Wolfe.

Tockus erythrorhynchus erythrorhynchus (Temminck)

Buceros erythrorhynchus Temminck, Pl. Col., livr. 36: sp. 19. 1823 (Senegal).

Riney collected a male red-billed hornbill on the plains west of Agadat, 700 meters altitude, on December 13, 1942, and Wolfe shot another individual south of Gura, July 26, 1942. Riney's bird shows active molt in the tail.

Family TIMALIIDAE: Babblers

Turdoides leucopygia leucopygia (Rüppell)

Ixos leucopygius Rüppell, Neue Wirbelth., Vög.: 82, pl. 30, fig. 1. 1840 (coast of Abyssinia).

Riney met with this northern race of the white-rumped babbler 40 km north of Asmara, 2,390 meters altitude, on January 9, 1943, when he collected a male and an unsexed specimen. This race has the whole forehead and forecrown white, while the four more southern subspecies have the white reduced or absent.

The male shows signs of active molt in the wings.

Family TURDIDAE: Thrushes, Chats, and Wheatears

Monticola solitaria solitaria (Linnaeus)

Turdus solitarius Linnaeus, Syst. Nat., ed. 10: **1**: 170. 1758 (Italy, *apud* Hartert).

The blue rock-thrush of central and southern Europe winters in northeastern Africa, along

with the race *longirostris* of western Asia. Riney collected a female 20 km south-southwest of Asmara, 1,930 meters altitude, on January 1, 1943, which agrees with the nominate form in its dark and brownish color (the western Asiatic form is paler and more grayish).

Oenanthe hispanica melanoleuca (Güldenstadt)

Muscicapa melanoleuca Güldenstadt, Nov. Com. Petrop. **19**: 468. 1775 (Georgia; Caucasus).

An unsexed specimen of the eastern black-eared wheatear was obtained by Riney 20 km-south-southwest of Asmara, 1,930 meters altitude, on January 1, 1943. The race is known to winter from Egypt to Darfur Province in the Angol-Egyptian Sudan and to Eritrea and to southwestern Arabia (Aden Protectorate).

Oenanthe lugubris (Rüppell)

Saxicola lugubris Rüppell, Neue Wirbelth., Vög.: 77, pl. 28, fig. 1. 1837 (Simen, Abyssinia).

The Abyssinian black chat was met with by Riney on January 1, 1943, when he collected an adult male and female 20 km south-southwest of Asmara, at an altitude of 1,930 meters. These two specimens are definite evidence that Zedlitz (Journ. für Orn. 1911: 85) was wrong when he suggested that this species was migratory in Eritrea, leaving for the south after breeding, and returning in the latter part of March. Together with December and January birds previously recorded from Ethiopia (Friedmann, U. S. Nat. Mus. Bull. 153, pt. 2: 135. 1937.) these examples indicate that the migration, if any, is very limited in geographical extent.

Both specimens are in fairly fresh plumage; the female has pale tips on the outer rectrices (curiously enough, only on the left side of the tail, but not on the right), the male has none at all.

Oenanthe isabellina (Temminck)

Saxicola isabellina Temminck, Pl. Col., livr. 79: pl. 472, fig. 1. 1829 (Nubia).

Riney obtained a female isabelline chat in the low brushland of the Asmara Plateau, 2,040 meters elevation, near Asmara, on January 1, 1943. The species breeds in Europe and east to Mongolia and winters in northeastern Africa, Arabia, and India.

Cossypha semirufa semirufa (Rüppell)

Petrocincla semirufa Rüppell, Neue Wirbelth., Vög.: 81. 1840 (Abyssinia).

In the dense forest of Monte Marara, 2,340 meters altitude, about 40 km north of Asmara, on January 9, 1943, Riney shot an example (unsexed) of this robin-chat. This must be about as far north as it is known to occur; I know of no published records north of Bogosland.

Family MUSCICAPIDAE: Old World Flycatchers

Bradornis pallidus bowdleri Collin and Hartert

Bradornis pallidus bowdleri Collin and Hartert, Nov. Zool. **34**: 52. 1927 (new name for *B. p. sharpei* Rothschild, 1913, not *B. sharpei* Bocage, 1894: Abyssinia).

One female was collected by Riney near Decamera, 2,000 meters altitude, on January 1, 1943. This race of the pale flycatcher inhabits northern Ethiopia (south to the vicinity of Adis Ababa) and Eritrea, where it lives on open bushy areas.

Batis minor erlangeri Neumann

Batis minor erlangeri Neumann, Journ. für Orn. 1907: 352 (Gara Mulata, near Harrar, Ethiopia).

Riney obtained an unsexed specimen (male by plumage characters) near Decamera, 2,000 meters altitude, on January 1, 1943. Inasmuch as this example agrees with Ethiopian specimens of *erlangeri* and shows no approach to the characters ascribed to *chadensis*, I have no hesitancy in so classifying it, although it extends the known range of *erlangeri* northward a very considerable distance. It was known previously from the Harrar area in central eastern Ethiopia, southwest to southern Shoa, and to Lake Stefanie.

Family MOTACILLIDAE: Wagtails and Pipits

Anthus richardi cinnamomeus Rüppell

Anthus cinnamomeus Rüppell, Neue Wirbelth., Vög., 103. 1840 (Simien Province, Abyssinia).

On January 1, 1943, Riney collected a female of this pipit about 15 km south-southwest of Asmara, at 2,040 meters altitude. The bird was seen on the ground in low brushlands. The specimen, which is in somewhat frayed plumage agrees well with others from Ethiopia.

Family LANIIDAE: Shrikes

Lanius collaris humeralis Stanley

Lanius humeralis Stanley, *in* Salt, Travels in Abyssinia . . . , Appendix, li, no. 4. 1814 (Chelicut, Abyssinia).

One female, collected by Riney 15 km south southwest of Asmara, 2,040 meters, January 1, 1943, is of this subspecies, which occurs from Eritrea and Ethiopia, south through eastern Africa (west to central Uganda), to Zululand and Natal.

Family PRIONOPIDAE: Wood-shrikes

Prionops cristata cristata Rüppell

Prionops (Lanius) cristatus Rüppell, N. Wirbelth., Vög., lief. 183: 30, pl. 12, fig. 2. 1837 (coast at Massawa).

Riney obtained an unsexed bird at Ghinda, 962 meters altitude, on February 2, 1943. The specimen is in very worn feathering.

Family STURNIDAE: Starlings

Lamprocolius chalybeus chalybeus (Hemprich and Ehrenberg)

Lamprotornis chalybeus Hemprich and Ehrenberg, Symbolae physicae, folio y: pl. 10. 1828 (Ambukol, Dongola).

A female, showing evidence of active molting in the wings, was collected by Riney 30 km from Asmara, 1,930 meters altitude, on January 1, 1943.

Family PLOCEIDAE: Weaverbirds

Sporopipes frontalis abyssinicus Mearns

Sporopipes frontalis abyssinicus Mearns, Smithsonian Misc. Coll. **56**(14): 7. 1910 (Abyssinia).

Three examples of the speckle-fronted weaver were collected by Riney, 2 males and 1 female, on the acacia plain between Nefasit and Decamera, elevation 1,852 meters, February 7, 1943. One of the males shows evidence of molting in the tail.

These specimens are somewhat darker on the upper surface of the wings than is the type, but this may be due to the fact that the latter is in very fresh plumage and has more extensive pale margins to these feathers.

Ploceus baglafecht baglafecht (Daudin)

Loxia baglafecht Daudin, *in* Buffon, Hist. Nat. (Didot's ed.), Quadrupeds **14**: 245. 1799 (actually 1802) (Abyssinia).

Riney collected a male, 40 km north of Asmara, 2,390 meters elevation, on January 9, 1943. This weaver is known to occur at altitudes of from 5,000 to 12,000 feet in Bogosland and Ethiopia.

Uraeginthus bengalus bengalus (Linnaeus)

Fringilla bengala Linnaeus, Syst. Nat., ed. 12, **1**: 323. 1766 ("Bengal"; Senegal substituted by Sclater, Syst. Avium Ethiop. **2**: 804. 1930).

One male and one female were taken by Riney on January 1, 1943 in low acacia-dotted open grassy country between Decamera and the Adi-Ugri Road, 2,000 meters elevation. The male had the testes enlarged. Both birds are in worn plumage.

I can see little advantage in accepting the recent suggestion that *bengalus* and its races are conspecific with the *angolensis* group. There is more to be said for Delacour's action in "lumping" *Uraeginthus* in the genus *Estrilda*, but even in this I hesitate to follow him as the cordon-bleus are a very distinctive section, at least, of the waxbill aggregate.

Family FRINGILLIDAE: Finches, Sparrows, and Buntings

Poliospiza tristriata tristriata (Rüppell)

Serinus tristriatus Rüppell, Neue Wirbelth., Vög.: 97, pl. 35, fig. 2. 1840 (Taranta Pass, Abyssinia).

Riney collected a female in the Bermuda grass at the base of the Asmara Plateau, at 1,930 meters elevation 20 km south-southwest of Asmara, January 1, 1943. This seedeater appears to range from altitudes of from 4,000 to 11,000 feet, and is reported (in literature) to be common in Eritrea and northern Ethiopia.

Fringillaria tahapisi septemstriata (Rüppell)

Emberiza septemstriata Rüppell, Neue Wirbelth., Vög.: 86, pl. 30. 1840 (Gondar, Abyssinia).

A male in fairly worn plumage was taken by Riney on January 1, 1943, 45 km from Asmara, 1,930 meters elevation.

This race of this rock bunting is characterized by the extensive rufescent area on the basal portion of the inner web of the outermost primary.

ZOOLOGY.—*Some echinoderms from Biak, Schouten Islands.*[1] Austin H. Clark and Frederick M. Bayer, U. S. National Museum.

Biak (or Wiak) is the largest and most easterly of the Schouten Islands, a small group of islands just north of Geelvink Bay, New Guinea, in approximately latitude 1°S. It is 45 miles long and 23 miles wide. It is a low island, not rising more than 50 feet above sea level except at the southern end where there is a hill 800 feet in height.

Until the late war Biak was regarded as of little importance. It was remote from the Netherlands East Indies capital of Batavia, and the natives, addicted to headhunting and other unpleasant practices, were hostile to strangers. Few collections of any kind had ever been made there, and no echinoderms have ever been recorded from the island.

During the war the junior author, then a member of a 5th Airforce Photo Reconnaisance Squadron, was fortunate enough to spend four months at Sarido village within a stone's throw of a luxuriant coral reef. This reef is a fringing reef of rather insignificant proportions. It is perhaps 200 yards wide at the most and approaches quite close to the shore, which is sandy in the small embayment in which Sarido stands, and rocky southward toward the point on which the airstrip is located. In the little bay the actively growing reef is somewhat farther from shore than elsewhere and is separated from it by a strip of slightly deeper water, from 3 to 5 or 6 feet deep at low tide, with a sandy bottom on which are scattered living and dead clumps of coral and patches of eelgrass and algae. This is a rather restricted zone, grading rapidly into the active reef zone.

The reef itself is covered with water at all but the very lowest tides when a few of the highest coral prominences are exposed. It is made up of great masses of living coral, huge rounded heads of massive species many feet thick and submarine "brier patches" of branched madrepores in which reef fishes of indescribable colors hide by day. It is not an algal reef of the type found in the Marshall Islands and generally throughout the Pacific. There is no prominent ridge of *Lithothamnion*, nor are these plants even present in noticeable numbers.

The coral masses afford precarious footholds, for the delicate *Acroporas* and other branched species are liable to give way, plunging one's foot into 4 or 5 feet of water and raking one's legs with razor-sharp edges in the descent. Among these coral masses are pools of deep water with sandy bottoms, providing a fine habitat for marine animals.

Two invertebrates especially force themselves on the attention of the collector, the giant clam, *Tridacna*, with its mantle rich shades of blue, green, and purple, and a starfish, *Linckia laevigata*, with a very small disk and long, rigid, cylindrical arms of the most outlandish blue imaginable. These two creatures are everywhere. Coral masses are studded with the multicolored zigzags formed by the clams, and the entire reef is dotted here and there on sand and coral alike with the brilliant blue 5-pointed stars.

The most interesting animals were less evident, and it required poking into dark crevices, turning over coral blocks, and stirring up sand pockets to find them. Occasionally one of the giant slate-pencil urchins, *Heterocentrotus mammillatus*, would be found in the open, though usually they were tucked away in remote nooks and crannies, their presence betrayed only by a stray spine or two projecting from a small opening, apparently much too small to allow the creature free passage. Cidarids could be found in similiar situations, though they were much less common.

Turning over coral heads was a simple way of finding interesting things. Brittlestars were, of course, under every one, and those with large enough recesses often contained comatulids of unusual beauty. The less conspicuous starfishes also were often found in such situations. The little sand pockets under the rocks produced very interesting mollusks, such as the venomous cone shells, *Conus textile*, *C. striatus*, and *C. geographus*, not to mention dozens of less conspicuous things such as abalones (*Halio-*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 7, 1947.

tis), several species of *Trochus*, *Mitra*, *Cymatium*, and many other genera.

The large starfishes *Culcita novaeguineae* and *Acanthaster planci* were found crawling about in the open, but because of their protective coloration were more often overlooked than seen. The latter is adorned with the most vicious 3-cornered spines imaginable. In collecting one of these the spines drew blood through a pair of heavy leather gloves.

Toward the outer reef the water deepens, the coral heads become more widely spaced, and, reaching the brink, one can look down the almost vertical wall into fathomless blue. Sharks were sometimes seen cruising along in the hazy middle distance, and always myriads of reeffishes, moorish idols, parrotfishes, pomacentrids, wrasses, scorpionfishes, and many others. To the right and left on almost every coral pinnacle could be seen a huge black or deep red comatulid, gently swaying in the aquatic breezes. These seemed never to stray from their own chosen perch, for on several visits to the same spot we found them unchanged.

The occurrence of *Heterocentrotus mammillatus* at Biak is especially interesting, for only *H. trigonarius* has been definitely recorded from nearby New Guinea. *Heterocentrotus trigonarius* occurs in the Philippines and generally throughout the Pacific islands. It is replaced by *H. mammillatus* in the Hawaiian, Bonin, and Riu Kiu islands, which is also found at Lord Howe Island, in the Murray Islands at the northern end of the Great Barrier reef, and at Cape Jaubert, Western Australia.

The specimens listed below are in the U. S. National Museum, and the numbers following the names are those in the catalogue of the Division of Echinoderms.

CRINOIDEA

Comantheria briareus (Bell), 4, E.6935, E.6937, E.6939, E.6961.
Comanthus bennetti (J. Müller), 4, E.6963, E.6970, E.6972, E.6976.
Comanthus timorensis (J. Müller), 5, E.6936, E.6954, E.6962, E.6874.
Comanthus parvicirra (J. Müller), 5, E.6841, E.6842, E.6966, E.6971.
Himerometra magnipinna (A. H. Clark), 7, E.6957, E.6958, E.6964, E.6965, E.6973.
Stephanometra spicata (P. H. Carpenter), 1, E.6939.
Stephanometra protectus (Lütken), 1, E.6843.
Lamprometra palmata palmata (J. Müller), 4, E.6959, E.6960, E.6969, E.6987.

ECHINOIDEA

Plococidaris verticillata (Lamarck), 1, E.6967.
Eucidaris metularia (Lamarck), 3, E.6968.
Mespilia globulus (Linné), 1, E.6951.
Heterocentrotus mammillatus (Linné), 1, E.6977.

ASTEROIDEA

Archaster typicus Müller and Troschel, 1, E.6980.
Protoreaster nodosus (Linné), 1, E.6830.
Culcita novaeguineae Müller and Troschel, 3, E.6979.
Gomophia aegyptica Gray, 1, E.6828.
Nardoa mollis de Loriol, 2, E.6981.
Linckia laevigata (Linné), 4, E.6982–E.6984.
Linckia multifora (Lamarck), 3, E.6986.
Linckia guildingii Gray, 1, E.6985.
Asterope carinifera (Gray), 1, E.6827.
Asterina cepheus (Müller and Troschel), 1, E.6831.
Othilia luzonica Gray, 1, E.6978.
Acanthaster planci (Linné), 2, E.6955, E.6956.

OPHIUROIDEA

Ophiodera brevispina (von Martens), 1, E.6950.
Ophiothrix longipeda (Lamarck), 1, E.6944.
Ophiocoma erinaceus (Müller and Troschel), 1, E.6952.
Ophiocoma scolopendrina (Lamarck), 2, E.6953.
Ophiomastix annulosa (Lamarck), 2, E.6949.
Ophiomastix lütkenii Pfeffer, 2, E.6948.
Ophiarthrum pictum (Müller and Troschel), 5, E.6946, E.6947.
Ophiarachna incrassata (Lamarck), 1, E.6943.
Ophiarachnella septemspinosa (Müller and Troschel), 1, E.6945.
Ophiolepis superba H. L. Clark, 5, E.6940.
Ophiolepis cincta Müller and Troschel, 2, E.6942.
Ophioplocus imbricatus (Müller and Troschel), 5, E.6941.

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OF THE

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VOL. 38 MAY 15, 1948 No. 5

PHYSICS.—*General survey of certain results in the field of high pressure physics.*[1]

PERCY W. BRIDGMAN, Harvard University.

In this lecture I shall attempt to present a general survey of those parts of the field of high pressure physics with which I have had direct contact, dealing first with technical matters of producing and measuring high pressure, and secondly with the physical phenomena which occur under high pressure.

With regard to technique, several different ranges of pressure are to be recognized. The first step was to devise a method of packing which should be without leak, since leak had limited the range of previous experiments. A packing was devised, shown in Fig. 1, which automatically becomes tighter the higher the pressure, so that any pressure is accessible up to the strength of the containing vessels. If the vessels are made of one-piece construction, from the best heat treated alloy steels, it is possible to reach pressures of 12,000 kg/cm^2 as a routine matter and on occasion for short intervals of time as high as 20,000. For many years my work was confined to this range, and in this range it proved feasible to measure nearly all the ordinary physical properties of substances. The next step was to give the pressure vessel external support which increases in magnitude at the same time the internal pressure increases. A simple method of doing this is to make the external surface of the pressure vessel conical in shape, and to push it into a heavy collar with a force which increases as the internal pressure increases, as illustrated in Fig. 2. With apparatus of this kind it is possible to make routine experiments up to 30,000 kg/cm^2 with volumes of the order of 15 cm^3, to get electrically insulated leads into the apparatus, and practically to repeat all the former work in the range to 12,000. I am still engaged in carrying out this program. An extension of the same technique on a smaller scale with capacities of the order of 0.5 cm^3 can be made up to 50,000 kg/cm^2. In this range all ordinary liquids freeze solid, electrically insulated leads cannot be got into the apparatus, and the phenomena which can be studied are limited to various volume effects, such as compressibilities and phase changes, including fusions and polymorphic transitions.

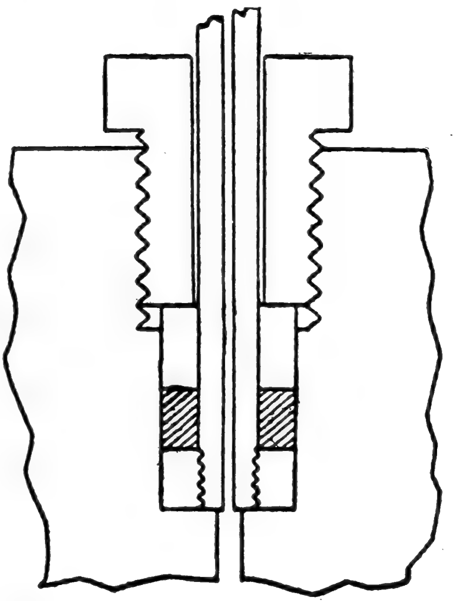

FIG. 1.—The general scheme of the packing by which pressure in the soft packing materials is automatically maintained a fixed percentage higher than in the liquid.

[1] Nobel Laureate Lecture delivered at Stockholm, Sweden, December 11, 1946. Reprinted by permission from the proof of the article for *Les Prix Nobel en 1946*.

The external support of the vessel is only one of the factors that make possible the extension of range from 12,000 to 50,000. No steel piston will support as much as 50,000; carboloy, however, the recently developed substance for tools formed by cementing a fine powder of tungsten carbide with cobalt, fortunately proves to have a compressive strength high enough for the purpose.

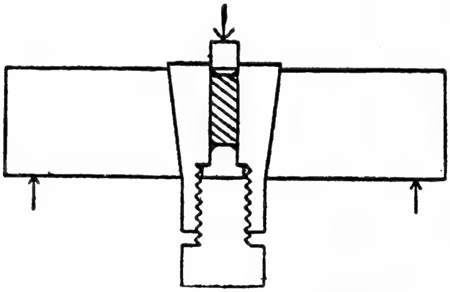

Fig. 2.—Illustrating the general principle of the method for giving external support to the pressure vessel in such a way that support increases automatically with the increase of internal pressure.

The next step in extension of range, from 50,000 to 100,000 kg/cm², demands still more effective support of the pressure vessel. This is done by immersing the entire pressure vessel in a fluid under pressures ranging up to 30,000 kg/cm². The pressure apparatus has to be made still smaller, the pistons are only 1.6 mm in diameter, and the capacity is only a few cubic millimeters. The pressure cylinder itself, as well as the pistons, is now made of carboloy with an external jacket of shrunk-on steel to give it greater strength. The piezometer is illustrated in Fig. 3. Even with this type of construction so great an extension of range as from 50,000 to 100,000 would not have been possible if it were not for a fortunate change in the properties of metals under pressure. At pressures of 25,000 kg/cm² ordinary grades of steel become capable of almost indefinite deformation without fracture, so greatly has their ductility been increased, as shown in Fig. 4. Even carboloy loses its normal brittleness and becomes capable of supporting higher tensile stresses without fracture than steel.

Up to the present, the compressibilities and polymorphic transitions of some 30 elements and simple compounds have been studied in the range to 100,000 kg/cm².

Much higher pressures than 100,000 can be reached in very small regions by constructing the apparatus entirely of carboloy, but up to the present no particularly important physical results have been attained in this range.

In addition to the problem of attaining the pressures, there is the problem of measuring them and measuring the effects which they produce. This demands in the first place the establishment of various fixed points. In the range up to 30,000 a sufficient number of such points has been established to permit measurements to an accuracy of about 0.1 percent. A transition of bismuth in the neighborhood of 25,000 gives one convenient such point. An essential part of the measuring technique is the utilization of the change of resistance of manganin under pressure, first suggested by Lisell at Uppsala. Above 30,000 the territory is not so well marked out; it is probable that the measurements to 100,000 have an accuracy of about 2 percent.

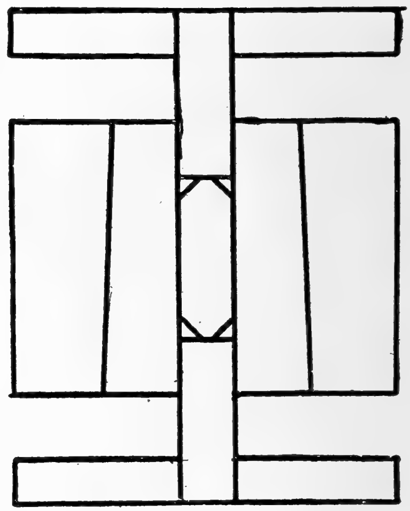

Fig. 3.—The miniature apparatus for reaching 100,000 kg/cm².

It is natural to think of volume compression as the simplest and most fundamental of all the effects of hydrostatic pressure, and for that reason it will be discussed first here. It is not, however, the simplest to measure experimentally, because the measurements immediately obtained are relative to the containing vessel, which is itself distorted.

Elaborate procedures may be necessary to eliminate the effect of such distortion.

The compression of gases is outside the range of this work; at pressures of 1,000 kg/cm^2 or more the densities of gases become of the same order of magnitude as those of their liquid phase, and there ceases to be any essential difference between gas and liquid. If the volume of any ordinary liquid is plotted as a function of pressure at constant temperature, a curve will be obtained which at low pressures has a high degree of curvature and a steep tangent, meaning a high compressibility, but as pressure increases the curvature rapidly becomes less and the curve flattens off. In Fig. 5 the volume of a typical liquid, ether, is shown as a function of pressure. For comparison, the curve of the most compressible solid, caesium, is also shown. Two different physical mechanisms are primarily responsible for the different behavior in the low and high pressure ranges. The low range of high compressibility is the range in which the chief effect of pressure is to push the molecules into closer contact, eliminating the free spaces between them. In this range individual substances may show large and characteristic individual differences. In the higher range the molecules have been pushed into effective contact, and the compressibility now arises from the decrease of volume of the molecules themselves. This effect persists with comparatively little decrease over a wide range of pressure. This effect is of course present also in the lower range of pressure, but there it is masked by the much larger effect arising from squeezing out the free spaces between the molecules. If one attempts to set up a formula for the effect of pressure on volume on the basis of measurements in the low range only, one will be likely to neglect too much the contribution from the compressibility of the molecules, with the result that the actual volumes at high pressures will be found to be materially smaller than the volumes which would be extrapolated from the low pressure formulas. This, as a matter of fact, has been a property of practically all the

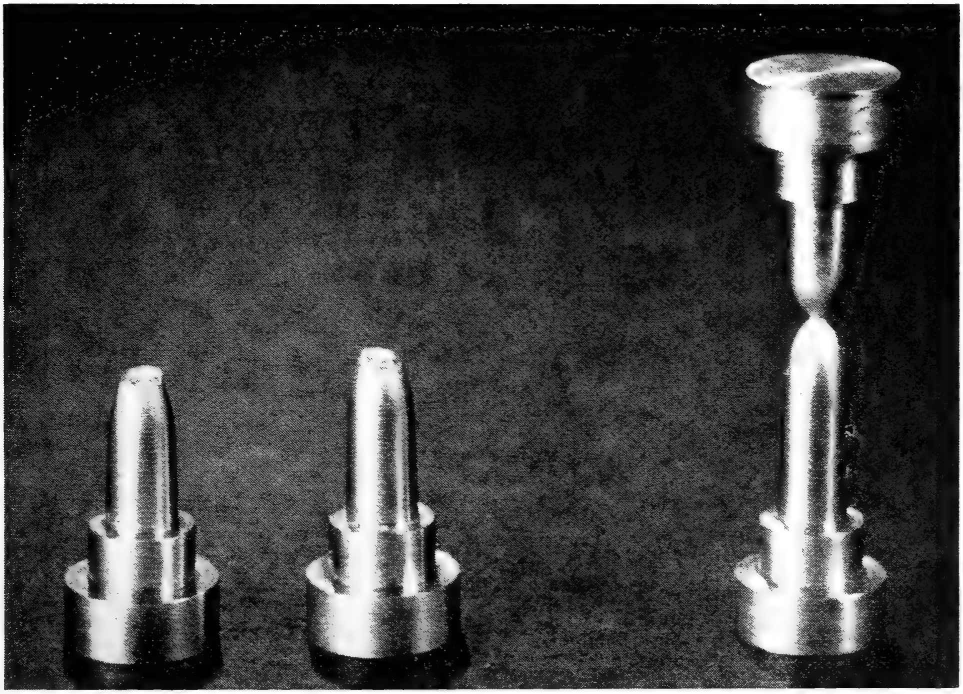

FIG. 4.—Illustrating the effect of pressure in increasing the ductility of steel. On the left, a piece of mild steel broken in tension at atmospheric pressure. On the right, the same steel pulled to a much greater reduction of area without fracture in a liquid at 25,000 kg/cm^2.

formulas that have been derived from low pressure data.

At high pressures, the volumes of ordinary organic liquids become surprisingly alike in spite of initial differences. To illustrate the rapid falling off of compressibility with pressure, the volume change in the first 5,000 kg/cm² is roughly the same on the average as the volume change between 5,000 and 50,000; the effect is accentuated by the fact that the volume decrement in the latter range often includes the volume discontinuity on freezing.

In the low pressure range, in which the molecules are being pushed into effective contact, one might expect effects depending on the shapes of the molecules, and that these effects would be highly specific with the liquid. This is the case. In the low pressure range a great variety of small-scale abnormalities are superposed on the larger scale uniformities, and these small-scale effects vary greatly from liquid to liquid. Thus there may be sub-ranges of an extent of a few thousand kg/cm² in which the compressibility increases with increasing pressure instead of decreasing as is normal, or the thermal expansion may also increase with increasing pressure instead of decreasing. Any satisfactory theory of liquids must ultimately give an account of these small-scale effects but for the present the large-scale effects must have first attention. When the theory of liquids does come to be written, the first step may well be to set up an idealized "perfect liquid" in analogy to the perfect gas which has played so important a role in the theory of gases. The experimental results at high pressures show sufficient uniformity in the behavior of all ordinary organic liquids to indicate that such an idealized perfect liquid is not too far from the actuality.

The compressibility of solids varies over a much wider range than does that of the ordinary liquids; caesium, for example, is 350 times more compressible than diamond. The highest compressibilities among solids, judging from indirect evidence, are probably to be found in solid hydrogen and helium. As in the case of liquids, the compressibility of solids normally drops off with increasing pressure. This would be expected in general because of the operation of a law of "di-

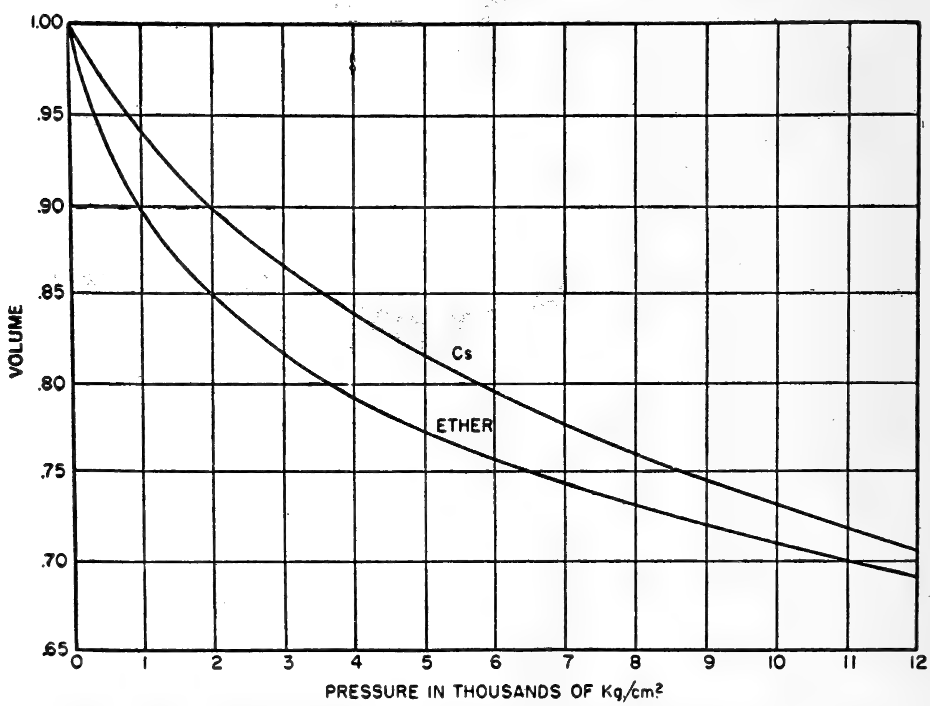

FIG. 5.—Volume as a function of pressure for a typical liquid, ether. The corresponding curve is also shown for caesium, the most compressible solid. The liquid is initially much more compressible than the solid, but at higher pressures is less compressible.

minishing returns," and is obviously necessary when pressure is raised indefinitely because if volume continued to decrease at its initial rate it would eventually become negative. For instance, the volume of caesium would become negative at a pressure of only 14,000 kg/cm^2 if it continued to decrease with pressure at the initial rate. In spite of the fact that the compressibility of solids on the average must decrease with increasing pressure, there is a very marked qualitative difference as compared with liquids. The initial phase of very rapid decrease is absent, and the decrease is spread more uniformly over the entire pressure range. The difference is to be accounted for by the lattice structure of solids; with increasing pressure the atoms retain their position in the lattice with the result that a smaller part of the free space between the atoms is available for occupancy as the centers of the atoms are forced closer together.

The volume decrements of a number of the more compressible solids are shown as a function of pressure up to 100,000 kg/cm^2 in Fig. 6. The curvature is in general very marked.

There is no thermodynamic necessity that the compressibility should decrease with increasing pressure, although this opinion has sometimes been expressed. Solid substances are known in which the compressibility may increase with increasing pressure over a comparatively wide range of pressure. The most striking example is quartz glass. The compressibility not only increases with pressure, but increases at an accelerating rate. This continues up to 35,000 kg/cm^2 and then abruptly stops. At this pressure there is a discontinuity in the derivative, a transition of the "second kind" in the nomenclature of Ehrenfest, and from here on compressibility decreases with rising pressure as is normal. The mechanism which is responsible for the low pressure effect abruptly ceases to act. Fig. 7 shows the relations.

So far we have been considering the effect of pressure on the volume of isotropic substances; this includes substances like glass and all cubic crystals. If the material crystallizes in some non-cubic system, the effects are more complicated. The compressibility is not the same in all directions, so that the shape of bodies composed of such crystals may change under pressure. The differences of compressibility in different directions may be large; thus zinc is eight times as compressible in the direction of the hexagonal axis as at right angles to it. Some difference in this direction might be expected, because the atomic spacing is greater along the axis than at right angles, but no simple consideration would lead to the expectation of differences as large as this. There is even one substance, tellurium, which has a negative compressibility along the axis. That is, when a single crystal of tellurium is subjected to hydrostatic pressure by a fluid in which it is completely immersed, it expands along the axis.

Considerable success has been achieved in calculating theoretically the effect of

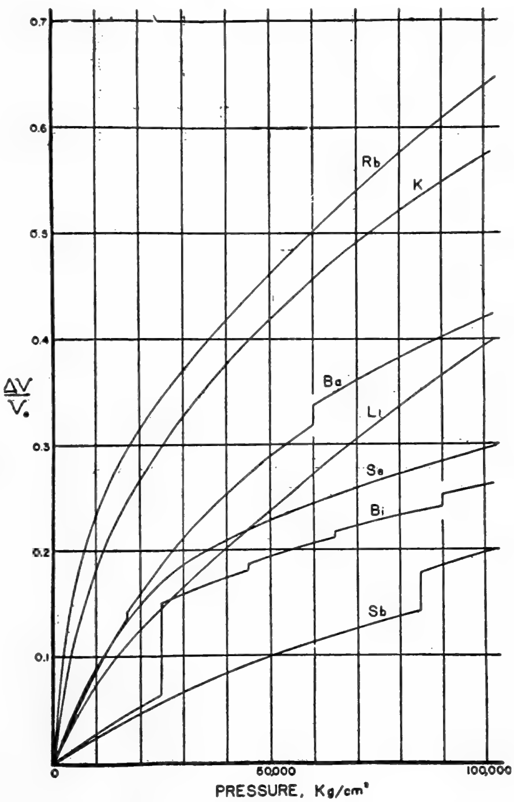

FIG. 6.—The volume compression of several elements up to 100,000 kg/cm^2. The breaks in some of the curves indicate polymorphic transitions.

pressure on the volume of simple solids. The first success was with simple ionic lattices of the type of NaCl by Max Born, who was able to get acceptable values for the lattice spacing and for the initial compressibility. He was not at first successful, however, in reproducing the change of compressibility with pressure, and even today complete success has not been attained in this regard. More complete results have recently been obtained for the alkali metals by applying the methods of wave mechanics. Bardeen has had surprising success in reproducing the entire volume curve over the experimental pressure range for the alkali metals. The calculations are particularly simple here because there is only one free electron per atom, and it turns out that the major part of the effect arises from the increase of kinetic energy of the free electrons arising from their decrease in effective wave length when the volume is decreased. Other metals, with more free electrons, are more difficult to compute, but it is anticipated that the difficulties are merely difficulties of the complexity of the calculation.

Theory is apparently not yet in a position to attack with much success the problem of non-cubic crystals.

We now consider the discontinuous volume effects arising from phase changes of various sorts. The simplest of these is the effect of pressure on melting. Historically the study of the effect of pressure on melting was approached with the anticipation that the effects would be found to be similar to the effect of pressure on vaporization, and in particular that there would be critical phenomena, so that above a certain pressure and temperature continuous passage would be possible between liquid and solid. It soon appeared, however, that the pressure scale of any such effects must be much more extensive than the scale of the critical effects between liquid and vapor, and that whereas pressures of a few hundred kg/cm^2 were adequate in the latter case, pressures of thousands of kg/cm^2 would be required to produce analogous effects for solid and liquid, if indeed they could be produced at all. With every extension of pressure range the probability of the existence of any such critical phenomena has become increasingly remote. Melting curves have now been followed up to 40,000 kg/cm^2; a number of these are shown in Fig. 8. The melting curves of all substances have certain qualitative features in common, so that it is appropriate to speak of "the" melting curve just as one may speak of "the" vaporization curve. In other respects, however, the situation with regard to melting is qualitatively different from that with regard to vaporization. In particular, all melting curves, that is, the curve of melting temperature against pressure, are concave toward the pressure axis with a curvature becoming less at higher pressures,

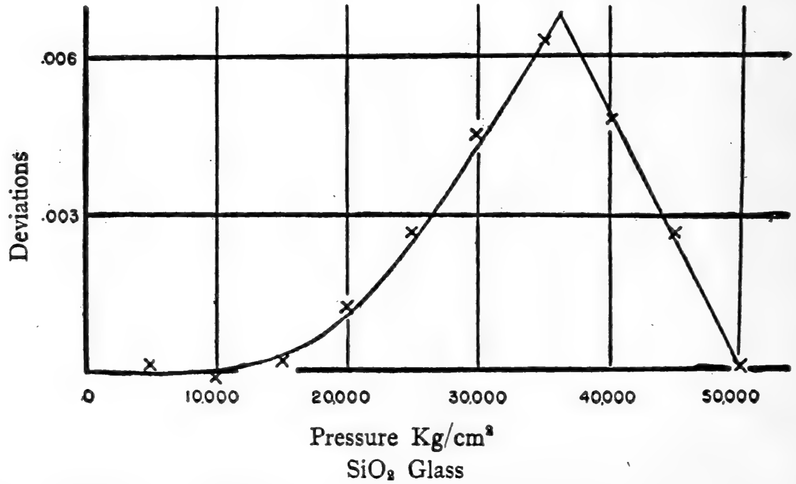

FIG. 7.—The deviations from linearity of the volume decrements of quartz glass for pressure increments of 5,000 kg/cm^2 plotted against pressure. The cusp in the curve marks the change from abnormal to normal behavior.

and the curve of difference of volume between liquid and solid as a function of pressure is convex toward the pressure axis with a curvature decreasing with increasing pressure. No critical point has ever been observed in the experimental range. If there were such a point outside the range, the latent heats and the volume difference between liquid and solid would have to vanish at a common pressure and temperature. Extrapolation of the curves for latent heat and volume difference indicates that neither of them will vanish at any finite pressure or temperature, to say nothing of both vanishing at the same pressure and temperature. The probability at present seems overwhelming that there can be no critical point between liquid and solid, at least for the type of substance investigated up to now, which includes organic substances of various types and a few metals. The same line of argument rules out the existence of other such features on the melting curve as a maximum temperature or an asymptotic temperature. In general, the melting curve rises to indefinitely high temperatures with indefinitely increasing pressure but at a diminishing rate, the curve becoming more nearly linear.

It is possible to show thermodynamically that if a substance expands when it melts, its melting temperature must rise with increasing pressure, and, conversely, it falls. There are only three substances which belong to the latter category in the ordinary range, water, bismuth, and gallium. Consistent with thermodynamics the melting curves of these three substances are found to fall. Furthermore, the curvature increases and the curves drop more and more rapidly as pressure increases. Such a state of affairs apparently cannot continue indefinitely. Nature extricates itself from the dilemma by the "liquidating" of such abnormal substances. Above a certain pressure the lattices in which these substances initially crystallize become unstable, and the lattice collapses into another lattice. The new lattice has a volume so much less than the former lattice that the solid phase is now more dense than the liquid, and from here on the melting curve rises as for other substances. The collapse of the lattice oc-

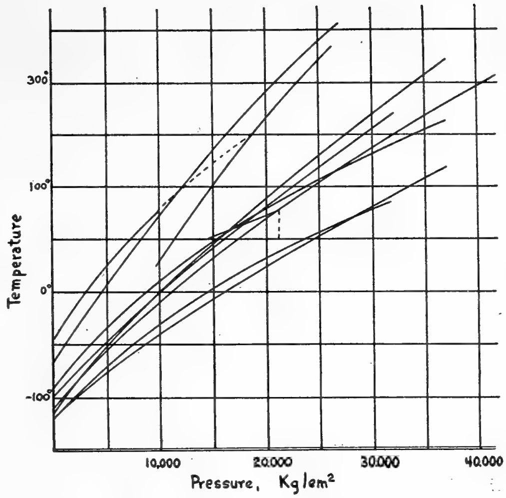

FIG. 8.—Melting temperature against pressure for a number of substances. At 15,000 kg/cm² the order of substances, reading from top down, is chloroform, chlorobenzene, chlorobenzene (second modification), water (ice VI), n-butyl alcohol, carbon bisulphide, methylene chloride, n-propyl bromide, ethyl bromide, and ethyl alcohol.

curs at a pressure of about 2,000 kg/cm² for water, at 12,000 for gallium, and at 25,000 for bismuth.

The phase changes of these three substances afford a particular example of polymorphism. The phase diagram of bismuth is shown in Fig. 9. Under pressure, polymorphism is a very common phenomenon; the number of instances increases with increase in the experimental pressure range and with increasing sensitiveness in the methods for detecting small discontinuities of volume. In the range from room temperature to 200° C and up to pressures of 50,000 kg/cm², roughly one-third of the substances examined have proved to be polymorphic. In the much greater range of conditions encountered in the crust of the earth, the presumption seems to be that no substance exists in the lattice with which we are familiar under laboratory conditions, unless perhaps the lattice is of a particularly simple type. The importance of such a conclusion for geophysics is obvious.

The thermodynamics of a polymorphic phase change is the same as the thermodynamics of melting, but beyond that there is little resemblance between the two phenomena; there is no such thing as "a" poly-

morphic transition curve as there is "a" melting curve. There are only three falling melting curves, and these disappear at higher pressures; there are many falling transition curves, and they become increasingly numerous at higher pressures. Between 12,000 and 50,000, 41 percent of the new transition curves are of the falling type. Transition curves may have horizontal or vertical tangents; melting curves have neither. Transition curves may have upward or downward curvature; melting curves are always concave downward. The difference of volume of two polymorphic phases may increase or decrease in the direction of increasing temperature along the transition line; the difference of volume between liquid and solid always decreases. The compressibility of the high pressure phase may be greater or less than that of the low pressure phase; the compressibility of the liquid is always greater than that of the solid. Substances are capable of existing in a number of polymorphic forms, and the complete mapping of the transition temperatures and pressures for all the forms may result in phase diagrams of great complication. Thus bismuth has six different phases; water, which has some striking analogies to bismuth, has seven phases. The most complicated phase diagram investigated to date is that of camphor, which has eleven phases.

There are only two generalizations with regard to polymorphic transitions that stand to date. The first is that critical points and continuous transitions between different polymorphic forms do not occur. If there were such points this would demand a continuous transition from one type of lattice to another, and this seems highly improbable, although perhaps not logically inconceivable. The second generalization is that transitions in the simple CsCl type of lattice in the direction of smaller volumes are not produced by pressure; this lattice seems to be of such a simplicity that it is not likely to be disturbed. This second generalization naturally rests on a much smaller number of examples than the first, and is correspondingly less secure.

We have so far been discussing transitions which are thermodynamically reversible; when pressure is released the origi-

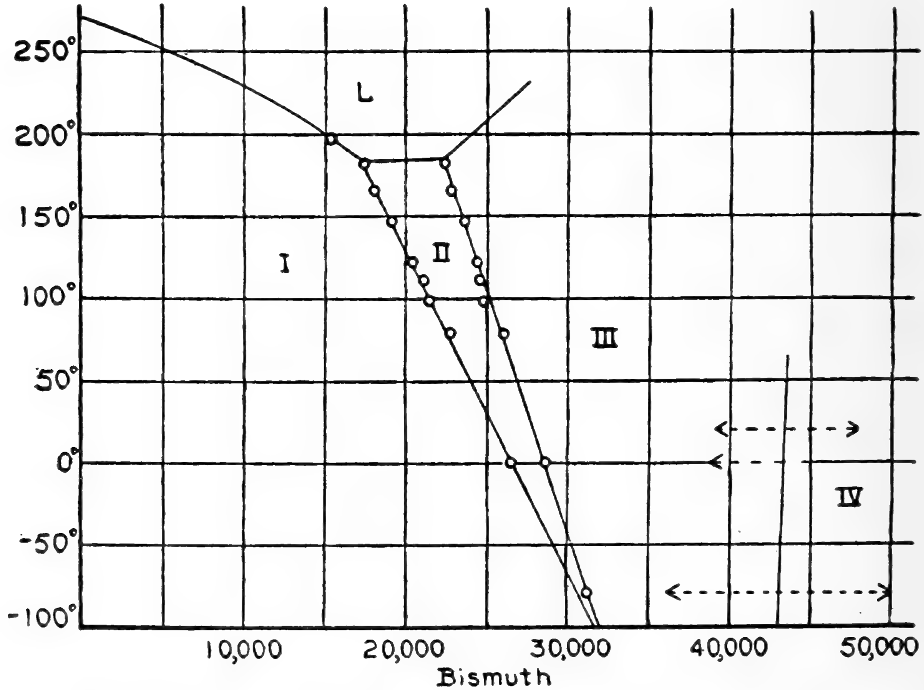

FIG. 9.—The phase diagram of bismuth. The arrows on the transition line III–IV indicate the pressure limits within which the transition runs with increasing or decreasing pressure.

nal form is resumed. In addition to these reversible transitions, the existence of irreversible transitions is to be recognized, that is, of changes effected by pressure which remain permanent when they have once taken place. Two well-marked examples of this have been found. The first was phosphorus. If ordinary yellow phosphorus is exposed to pressures above 12,000 kg/cm^2 at temperatures above 200° C, it is permanently changed into a black solid much like graphite in appearance and like it a conductor of electricity, although yellow phosphorus is a good insulator. This remained the only example for many years. Recently I have found that ordinary liquid CS_2 may similarly be changed permanently into a black solid at temperatures in the neighborhood of 200° C and by pressures of the order of 40,000 kg/cm^2. This black substance is definitely not a mixture of sulphur and carbon, which one might at first expect, but is apparently a unitary substance, truly a black solid form of carbon bisulphide. It has been suggested that the structure may be that of a single giant molecule like the known structure of SiO_2, which from the atomic point of view is very similar. It is fascinating to speculate that there may be many other common substances which may be pushed by sufficiently high pressures over a potential hill of some kind permanently into some hitherto unknown form. Until we have theoretical understanding of these two known permanent transitions, we can not help attaching a certain reasonableness to the assumption of the possible existence of other such substances. In fact, there is experimental evidence that many other such transformations may be effected. In experiments in which I combined high shearing stresses with high hydrostatic pressure I have observed some cases of irreversible transitions to forms already known, and have also observed a large number of color changes, which are the indication of some sort of permanent change. It was not possible to establish whether new substances were formed under these conditions because the quantities of material involved were too small to permit satisfactory analysis.

We pass now to other sorts of pressure effects. Perhaps the simplest of these to measure are the effects of pressure on electrical resistance. Measurements have been made at room temperature or higher up to 30,000 kg/cm^2 and at the temperature of liquid air to 7,000. At low temperatures there is a natural limit to the pressure range imposed by the freezing of the medium transmitting pressure, which in this case was gaseous nitrogen. Fig. 10 shows the effect of pressure on the alkali metals at room temperature up to 30,000 kg/cm^2.

In the first place, there is a specific effect of pressure on resistance; the pressure coefficient of resistance is in general of the order of magnitude of ten times greater than the volume compressibility. This would involve as a corollary that the effect of pressure on the resistance of a highly compressible metal is greater than on a metal of low compressibility. This is indeed true in general, but exceptions are common. The resistance of perhaps three-quarters of the metals decreases with increasing pressure; as is to be expected, the rate of decrease itself decreases with increasing pressure, that is, the curve of resistance against pressure is convex toward the pressure axis. On the other hand, there are several metals, of which lithium, strontium, and bismuth are examples, whose resistance increases under pressure. For these metals, surprisingly, there is a law of increasing returns, that is, the rate of increase of resistance itself increases with increasing pressure. This means that for these metals also the curve of resistance against pressure is concave upward. Finally, there are a few metals which combine both types of behavior, that is, the resistance initially decreases, then passes through a minimum, and then turns upward. Examples are caesium, rubidium, potassium, and barium. It would appear, therefore, that the upward curvature is common to all metals, and that all resistance curves may be regarded as pieces of one single curve, the only difference for different metals being that what might be called the intrinsic zero of pressure is differently situated with respect to atmospheric pressure for different metals.

Considerable success has been achieved by theoretical physicists in explaining theo-

retically the effect of pressure on resistance. As might be expected when effects departing so largely from linearity are concerned, we can recognize the presence of at least two different mechanisms working in opposite directions. There is in the first place an effect of pressure on what is the analogue of the electron free path in the old electron gas theory of metallic conduction. This is connected with the change of dimensions, and in general works in the direction of an increase of free path, that is, a decrease of resistance, with increasing pressure. In the second place, there is a rearrangement of the energy levels, and this may, when the energy bands are nearly completely occupied, work in the direction of a change in the effective number of free electrons. Deeonding on the details of the atomic relations, this effect may be either an increase or a decrease. The calculations have been carried through approximately in a few simple cases. It turns out that the increase of resistance of lithium with pressure is due to the preponderating effect of a decrease in the effective number of free electrons.

The effect of pressure on the electrical resistance of single crystals is sometimes very complicated. If the crystal system is cubic, the material behaves electrically like an isotropic body, but if the system has lower symmetry, there may be differences in different directions. In antimony, for example, the sign of the pressure effect is different in different directions. There are directions in the crystal for which the resistance passes through a maximum with increasing pressure, whereas for other directions the resistance decreases with normal curvature.

The resistance of some semi-conductors may be decreased by such large amounts that they approach the absolute resistances characteristic of the metals. An early investigation in this field was made on

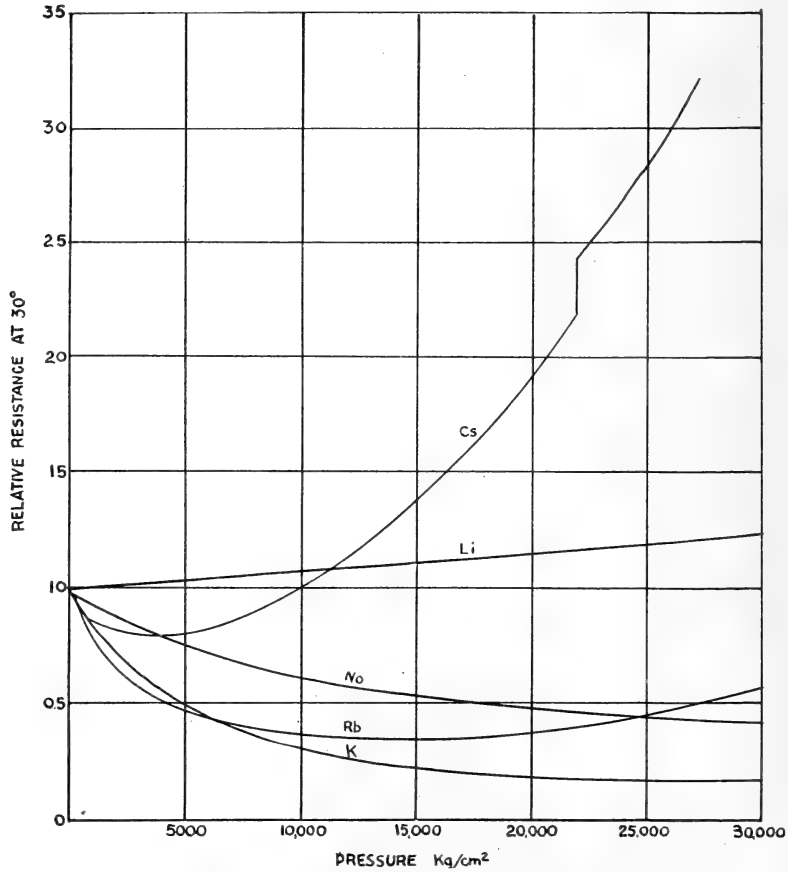

Fig. 10.—The relative resistances of the alkali metals up to 30,000 kg/cm². The break in the curve for caesium is due to a polymorphic transition. Potassium has a very flat minimum near 23,000.

selenium and silver sulphide by Montén in Uppsala. At higher pressures, tellurium approaches the properties of a metallic conductor under 30,000 kg/cm². Not only does the absolute value of the resistance drop to a characteristically low figure, but the temperature coefficient, which initially is negative, reverses sign under high pressure and becomes positive like that of the metals proper. Theory is as yet hardly in a position to explain these complicated effects, either in single crystals or in semi-conductors.

Closely related to the electrical conductivity of metals is their thermal conductivity; the relationship is expressed by the approximate equality of the Wiedemann-Franz ratio of electrical to thermal conductivity for all metals. Under pressure, thermal conductivity changes as well as electrical conductivity. It is much more difficult to measure than electrical conductivity, and satisfactory measurements have been made only for a few metals and those up to only 12,000 kg/cm². It appears that for these metals the Wiedemann-Franz ratio is approximately independent of pressure.

The effect of pressure on the thermal conductivity of liquids is much larger than on that of metals, and is much easier to measure. In general, the thermal conductivity increases for ordinary liquids under a pressure of 12,000 kg/cm² by a factor varying between 2 and 3. The effect on water is smaller; at 12,000 the increase for it is only 50 percent. There is a close connection between the effect of pressure on thermal conductivity of normal liquids and the effect of pressure on the velocity of sound in the liquid. That is, thermal conductivity in a liquid is primarily a mechanical affair; heat is transferred by microscopic mechanical waves travelling with the velocity determined in the conventional way by the compressibility. The small effect in water is associated with the small change in the compressibility of water brought about by pressure.

Another property of metals obviously related to electrical and thermal conductivity is the thermo-electric characteristics. These properties are also affected by pressure. In general, a metal under pressure behaves thermoelectrically differently from the same metal not under pressure, so that a thermo-

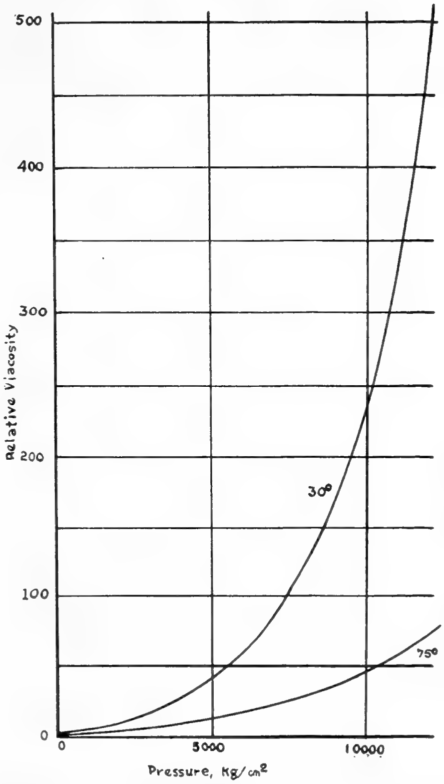

Fig. 11.—The effect of pressure on the viscosity of i-butyl alcohol.

couple may be made with one branch of any ordinary metal and the other branch of the same metal exposed to hydrostatic pressure. Under a pressure of 12,000 kg/cm² the thermoelectric power of such couples may be as large as that of ordinary couples composed of two entirely different metals. A number of such "pressure couples" have been investigated. The effects are complicated; there is not any universal rule with regard to the sign of the effect. There may be reversals of sign and large departures from linearity. No satisfactory theory of these effects has been formulated. At present one can only draw the conclusion that the interplay of several different mechanisms must be involved.

The largest of all the pressure effects studied to date is on the viscosity of liquids. In general, viscosity increases under pressure at a rate increasing rapidly with increasing pressure. The curve of viscosity against pressure usually rises exponentially with pressure and sometimes more rapidly than exponentially. In Fig. 11 is shown

the viscosity of i-butyl alcohol at 30° and 75° at pressures up to 12,000 kg/cm^2. The total rise may be by as much as a factor of 10^7 for a pressure increase of 10,000 kg/cm^2 (for eugenol). The rate of rise is definitely linked with the complication of the molecule, and is greater the more complicated the molecule. For the comparatively simple liquid water the rise of viscosity under 10,000 kg/cm^2 is by a factor of only 2 or 3 and for monatomic mercury by only 30 percent. For methyl alcohol the increase is by a factor of 10, for propyl alcohol by a factor of 100, and for amyl alcohol by a factor of 1,000. In the last few years the theoretical physicists have had considerable success in accounting for the effect of pressure on the viscosity of liquids.

EDITOR'S NOTE

Readers of Professor Bridgman's Nobel Lecture may be interested also in his remarks on the subject "Science and Freedom" that he made on January 11, 1947, at a dinner given in his honor by the Dean of the Faculty of Arts and Sciences of Harvard University at the Harvard Club of Boston. The address is here reprinted from the Isis **37:** 128–131. 1947, by the kind permission of Dr. George Sarton, editor of that journal. In introducing Professor Bridgman's remarks in the Isis, Dr. Sarton wrote: "They are of great interest to historians of science because they reveal the afterthoughts which do not appear in [his] scientific papers, nor even in the philosophical ones, yet which are essential for the understanding of a man's personality. The document . . . is of great value for the 'new humanists,' who wish to understand not only the technical aspects, but also the human factors, without which there would be no science, or without which science would lose its meaning and its grace."

SCIENCE AND FREEDOM: REFLECTIONS OF A PHYSICIST

By Percy W. Bridgman

This will not attempt to reproduce exactly what I said at the dinner on January 11, 1947, but I shall avail myself of the suggestion of Dr. Sarton to make a partly imaginary speech, composed of parts of what I actually said, and of what, in the light of afterthought, I wish I had said. I shall not attempt to reproduce a number of the more or less personal and informal details, but shall confine myself to matters of more general interest.

Of all the conditions of my work which in retrospect appears most important, and of which at the time also I was keenly conscious, freedom of investigation is outstanding. There has never been any suggestion from any outside source as to the nature of my investigations. Even in the early days, when I sought and obtained the maximum relief from teaching and administrative duties for the ostensible purpose of more complete devotion to my research, no attempt was made by the University authorities to impose as a condition that I continue to devote myself to high pressure investigation or even to investigation itself. The apparent attitude of the authorities was that if you are going to gamble that you have found a good man, a gamble without strings attached is the most likely to succeed. Any consistency which my experimental program may have shown has been a consistency imposed entirely from within; this I believe to be the proper source of consistency. In spite of the fact that I have in the main followed one guiding experimental idea, I have nevertheless at all times felt free to pursue other lines of interest, whether experiment, or theory, or fundamental criticism.

Another outstanding characteristic of my work has been the smallness of its scale. Not only is the apparatus itself small, in fact becoming smaller the higher the pressure, because of inherent physical limitations on strength,

but I have never had more than two or three students at a time or a couple of assistants. The result has been that I have been able at all times to maintain the closest contact with the details of the work, and also have been able to conserve the requisite amount of leisure. Both of these features have been of the highest importance. In advancing into new territory, as in this high pressure work, the necessity is continuous for the development of new methods and new ideas. For me, at least, new ideas germinate only in an atmosphere of leisure. I have to immerse myself in a problem and then let it gestate in my brain, without the distraction of other interests, if I am to expect the solution to come sauntering into my mind when I wake up two or three mornings later. In this process manual cooperation plays a great part. Adjoining my laboratory is my machine shop; in fact, it is an integral part of the laboratory to which I can repair and stimulate inspiration by working out half-formed ideas with my own hands. Not only do I have enough leisure so that I can work in the shop with my own hands on occasion, but I am also able to carry through my own experiment, including making all the readings, myself. I find this necessary if I am to have confidence in the results of some method not hitherto tried. There are too many pitfalls of unanticipated sources of error, which often require ingenuity for their elimination, and which may take much time to discover if one is only watching from the side lines. I have been able to make it an invariable practice to stay with each new method long enough to get material for a complete paper, before turning the method over to an assistant for more or less routine application to a large number of substances. Not only this, but even when an assistant makes the experiment and the readings, I have always made the computations and written the paper myself. This gives me a confidence in the results not possible when working on a larger scale. Another great advantage of working on a small scale is that one gives no hostages to one's own past. If I wake up in the morning with a new idea, the utilization of which involves scrapping elaborate preparations already made, I am free to scrap what I have done and start off on the new and better line. This would not be possible without crippling loss of morale if one were working on a large scale with a complex organization under one.

Another characteristic of the field in which I have been working is that it is not a particularly popular field, so that there have been comparatively few workers in it and correspondingly little competition. This has both advantages and disadvantages. It is an advantage that one can do his work with no sense of hurry, so that there is little temptation to make premature announcements, and should questions arise one can take the time to repeat the experiment or make other modifications that will clear up the matter. Also, the order in which the problems are attacked can be the order of greatest scientific economy, rather than the order of a competitive politics. On the other hand, the principal disadvantage, obvious enough to everyone, is that the investigator loses the stimulation of conversation with his colleagues on mutual problems. Just how important this stimulus is will depend in considerable measure on the individual investigator; some may find it well nigh indispensable, whereas others may be much less dependent on it. I myself have been able to get along in considerable measure without it. Even at scientific meetings, which every physicist seems to have to attend at intervals for rehabilitation of his inner man, the stimulus which I have received has not been detailed and specific, but rather general, in suggestions of trends and areas of coming interest. It has, I think, been a happy circumstance that my field, although obviously narrow in the sense that pressure is a highly specialized physical parameter, nevertheless from another point of view has been exceedingly broad. For the general problem has been no less than to determine the effect of pressure on all physical properties, and it therefore covers the entire reach of physical phenomena with the exception of such things as vacuum tube phenomena.

Mention of the stimulus of conversation with one's colleagues naturally prompts one to consider the increasing trend during the last few years to large-scale cooperative enterprises among physicists. The reasons for this are obvious in the enormously increasing size and expense of the apparatus necessary for modern physical research, such as the cyclotrons and the piles of nuclear physics. Although we may recognize that such instruments are necessary, we may nevertheless deplore some of the consequences. Up to now ideas have been in such a rapid state of flux that the instrument itself has been continually evolving, with the result

that most physicists in this field have been spending an increasingly large fraction of their time on the purely engineering job of the design and construction of new and better instruments and correspondingly an increasingly small proportion of time on the calculation of results and rumination on their significance. The competition in this field is intense; rivalry between different groups at different universities can offer little opportunity for leisure or the scholarly digestion of results before publication. Within the last year there has been one glaring example of hasty publication of a spectacular result of such presumptive importance as to start a rush of other investigators into the field, only later to be withdrawn as erroneous because of inadequate consideration of factors which obviously were crying for evaluation in the beginning. Not only is there haste because of competition, but there is haste because of financial considerations. The apparatus is so expensive that consideration of the overhead demands that the apparatus be kept in operation for twenty-four hours a day, and this is not conducive to a feeling of leisure. Each of the teams which is the slave of one of these instruments has to be driven by some one at the head who has the ideas. There is danger here that all the rest of the team will pick the brains of one man, with an ultimate decrease in the number of physicists in the community capable of independent and critical thought. Still worse, the physicist who should be directing his team by his creative ideas is likely to be so swamped by the administrative details of the large enterprise under him that he is overwhelmed and his purely scientific activity destroyed. This is well known to have happened, at least temporarily, in the case of one of the new mammoth calculating machines, machines whose ostensible purpose is to free the scientist from drudgery and make possible the creative use of his time. Doubtless some physicists have the natural knack of being able to work together harmoniously and perhaps even efficiently in teams, and perhaps others can acquire it, but I believe there are many who are permanently unfitted for effective cooperation in this way, and it will be a major loss if they are not able to find a niche in which they may function.

During the war practically all the physicists in this country were diverted to war work of one sort or another, and a large part of them were engaged in large-scale enterprises which involved team work developed to its maximum efficiency, with the consequent and necessary submergence of the individual. The older men, who had previously worked on their own problems in their own laboratories, put up with this as a patriotic necessity, to be tolerated only while they must, and to be escaped from as soon as decent. But the younger men, who had been drawn into the maelstrom before starting work for their Ph.D. degree, had never experienced independent work and did not know what it is like. Some of these younger men will continue in government work; others who return to academic circles will there join in the teams serving the mammoth instruments. The result is that a generation of physicists is growing up who have never exercised any particular degree of individual initiative, who have had no opportunity to experience its satisfactions or its possibilities, and who regard cooperative work in large teams as the normal thing. It is a natural corollary for them to feel that the objectives of these large teams must be something of large social significance. The temper of the rising generation is recognizably different from that of the older. I may mention one example with which I have had personal acquaintance. The Association of Cambridge Scientists was one of many similar associations formed soon after the dropping of the atomic bomb on Hiroshima to consider all the implications of the situation thus created. In the early days of the Association the May-Johnson bill was a matter of much concern. With regard to this there was in the ranks of the Association a cleavage of attitude almost exclusively along lines of age. The older men were troubled and concerned by the threats to scientific freedom contained in the bill, whereas the younger men were not at all concerned about this, but took the opposite view that it was on the whole a rather base and self-indulgent thing for the individual not to be willing to sacrifice his scientific freedom on the altar of the good of society. The young men, never having experienced scientific freedom, did and could not see that the question of self-indulgence does not enter at all into the situation, but the existence of science itself, which I think all conceded to be a social good, is impossible without scientific freedom.

The increasing amount of administrative work falling on some of the scientists compos-

ing the large teams has a parallel in the ever increasing amount of routine administrative work expected from the members of a University faculty. As I look back on the forty years of my work there can be no question but that the fraction of the time of the average faculty member spent in routine of administrative or other sorts has increased unconscionably. There seems to be a natural law operating here; the larger an institution becomes, the more cumbersome and less efficient it becomes. One might think that when the institution becomes ten times as large it would have ten times as much business and ten times as many people to do it, so that each individual would need to give only the same amount of time. But it does not work this way; it is more like the development of a telephone exchange, which when it increases by a factor of n has to provide for the handling of factorial n as many combinations. Each new functionary in a University has to justify himself, which he does by exacting attention from every member of the faculty. When, for example, the office of archivist is created, *every* member of the faculty is asked to provide material for the archives. Ten times as many officials tend to demand ten times as much attention from *each* member of the faculty. In a recent number of the Scientific Monthly there was an amusing and satirical article depicting the eventual extinction of the human race by suffocation in its own intellectual effluvia. It is well known that every large library tends to increase in size geometrically with the simple arithmetical passage of time. Why this should have to be true does not seem to have been explained, but it is an undoubted description of the observed behavior of the human animal. Unless some way can be discovered of breaking the cycle, the logical final result is catastrophic. In the past the cycle has been broken by wars and the collapse of civilizations. In the hoped-for brighter future in which war has been eliminated, some specific means will have to be devised to cope with the situation. The satirical article portrayed the consequences of the inability of the human race to devise an adequate means. It is no less a problem to devise a means by which the time of the members of university faculties may be saved for creative effort. Otherwise creative science will be driven to other asylums, if indeed it is not destroyed.

As I look to the future I am therefore troubled by two misgivings: that there will be less and less place for the small individual experimenter, and that the time of all of us will be increasingly commandeered by administrative mechanical details. In view of these misgivings I cannot help wondering as I look back on the past whether, if I were to start over again now, I would be able to do again what I have done.

CHEMISTRY.—*A method for the determination of certain metals present in minor concentration in various substances.*[1] N. HOWELL FURMAN, C. E. BRICKER, and BRUCE McDUFFIE, Princeton University. (Communicated by JAMES I. HOFFMAN.)

This paper presents an account of a systematic scheme for the determination of certain metals in a variety of substances. The scheme at first was directed toward the estimation of minor amounts of a few other metals that were found to occur in uranium or its compounds and salts. The method was gradually modified and extended in scope from 1942 to 1945 with the aid of G. P. Haight, Jr., J. A. Nyitrai, and others. The proved applications of the process, in addition to those already mentioned, include the estimation of minor amounts of various metals in the salts, alloys, or nearly pure metallic specimens of Ba, Be, Ca, Mg, and Na. From the experience thus far obtained it appears probable that the method could be applied to the testing of many other pure metals, their alloys, or compounds. The method is also applicable to the collection of the traces of metals that may occur in organic compounds or in

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materials of biological and pharmaceutical interest.

The original problem had to do with the detection or the determination of certain metals of the hydrogen sulphide group, notably copper, cadmium, lead, and molybdenum, or the detection of copper, cadmium, iron, etc., in lead and its salts, or in bismuth and its compounds. It was therefore natural to explore the possibilities of mercury cathode electrolysis as a preliminary to polarography and colorimetry. The pioneer work of E. F. Smith on mercury cathode separations was at once utilized (1942) in connection with the estimation of minor amounts of cadmium in lead or bismuth or in lead compounds.

USE OF A SMALL MERCURY CATHODE TO COLLECT SMALL AMOUNTS OF METALS

The majority of the procedures that were later developed in detail centered around the use of a small mercury cathode as a collector for minor amounts of metals which were electrolyzed into the cathode under the conditions chosen. The mercury cathode was then drained into a weighed silica combustion boat without interrupting the current, and after removal of the mercury by distillation in a current of nitrogen the residues were weighed and dissolved and the conditions were adjusted for the application of polarography. After the polarographic estimations the residual solution was further utilized for certain spectrophotometric determinations. The solution, from which the electrodeposited metals had been removed by electrolysis, was examined systematically by extractions and colorimetric procedures for minor amounts of other metals, e.g. Mo, Fe, Ti, and V (*1*).

This method of concentration has very decided advantages prior to polarography because the supporting electrolyte can be controlled very simply for the estimation of minor amounts of metals recovered from a great variety of samples. The method has been found useful for the concentration of materials prior to spectrophotometric or spectrographic estimations. For routine application to a given material the weight of the residue from the mercury distillation gives an idea of the gross contamination of the material by the electrolyzable metals. Chance contamination of some part of a sample can be detected by virtue of the fact that a very large sample may be examined.

The general facts of electrolysis into a mercury cathode have been summarized as follows (*2*): The following metals singly or in association are quantitatively deposited in a mercury cathode: Cu, Ag, Au, Zn, Cd, Hg, Ga, In, Tl, Ge, Sn, Bi, Po, Cr, Mo, Re, Fe, Co, Ni, Rh, Pd, Ir, Pt. Further Pb, As, Se, Te, and Os are quantitatively separated from the solution, but are not necessarily deposited in the mercury. Mn, Ru, and Sb are partially separated from the solution.

The foregoing general facts had not been studied exhaustively in the minor concentration ranges in which we were interested, nor had the recovery of various metals by electrolysis into mercury and distillation of the latter been studied, although the recovery of gold after amalgamation is a well-known process.

Oxidation-reduction buffers.—In the electrolysis of specimens of which the major constituents may form oxidation-reduction systems such as the $U^{IV}-U^{III}$, $Ti^{IV}-Ti^{III}$, $V^{III}-V^{II}$, etc., the list of metals that are completely deposited in the mercury is curtailed because the cathode potential is not depressed far enough to reach the level necessary to deposit some of the metals. For example, from rather concentrated solutions of uranium sulphate no Mo, Cr, and Mn are deposited under conventional conditions of electrolysis. A further point that we have noted is that the level which the cathode reaches is affected by the deposition of traces of platinum, iron, copper, etc., on the mercury. These and other metals tend to lower the overvoltage of hydrogen deposition and to make the removal of certain metals less complete. Iron under some conditions is completely removed from a solution containing uranium but from concentrated solutions the removal is uncertain and it is necessary to test for iron both in the mercury deposit and in the aqueous solution after electrolysis.

The details of electrolysis, distillation, and colorimetry can best be described in the

following outline of the experimental development:

EXPERIMENTS AND PROCEDURES

The scale of operation was set up primarily for the analysis of micro-amounts of metals. The apparatus was so chosen that distillation residues in the range from 10 micrograms up to 5 mg of material could be handled. The sample size is adjusted so that the material electrolyzed and left after distillation will be in this range. This scale of operation is well suited to polarography. In general residues between a few tenths of a mg and 1.5 mg were handled so that the process is a true microprocedure from this point.

Apparatus and materials.—Silica dishes of 250 ml capacity or smaller were used in the preparation of solutions except for fluorides which were treated in platinum dishes.

The reagents used to dissolve the samples were at first redistilled from a silica still for acids or from Pyrex for distilled water. Redistilled mercury was used. Later it was found feasible to use analytical reagent acids and to run frequent reagent blanks through the whole process.

Electrolysis cells of special design as shown in Fig. 1 were used. It is important to have the wire leading to the cathode terminate as near the stop-cock as possible. Anodes of platinum alloyed with 10 percent of iridium are satisfactory. The mercury cathode is drained into a silica combustion boat 14 by 75 mm and 10 mm deep, with handle. Silica beakers of 150 ml capacity are used for dissolving the deposit.

A 12-inch split tube furnace of conventional design is used for the distillation. The nitrogen that is used to sweep out the mercury is not freed from air.

A recording polarograph, preferably of the Heyrovsky type is desirable. The instrument that was used in the development of the method has been described in the literature (*3*).

DEVELOPMENT OF PROCEDURES

The initial experiments were made by electrolyzing exhaustively a solution containing a large amount of the substance to be tested. The first mercury cathode was drained out and washed out with a little mercury. Then with a fresh mercury cathode a known addition of any metal to be tested was made, and the electrolysis was repeated and the mercury was drained out, distilled, and the residue tested. Since cadmium did not occur in the reagents, as proved by frequent blank tests, the extent of recovery of varying amounts of cadmium may be used as an illustration of the effectiveness of the method, Table 1.

TABLE 1.—TYPICAL RECOVERIES BY THE PROCEDURE

Cadmium added	Cadmium recovered	Percent recovered
mg	*mg*	
0.010	0.0095–0.010	95–100*
0.100	0.095 –0.100	95–100*
0.50	0.45 –0.50	90–100*
1.00	0.935	93.5
2.00	1.94	97
2.50	2.56	102
3.00	2.94	98
4.00	3.89	97
5.00	4.79	96

* Where a range is given several individual determinations were made.

A number of similar experiments were made with small amounts of various sub-

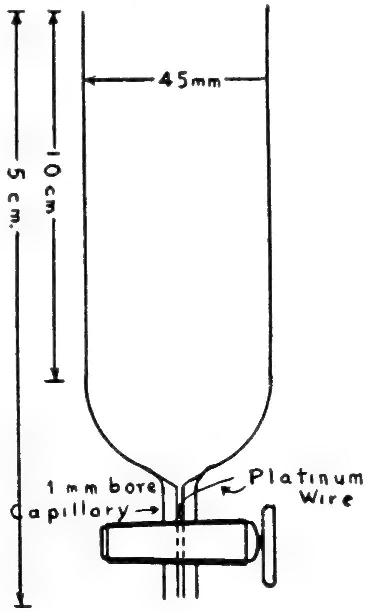

FIG. 1.—Cell for electrolysis. The cell is provided with a lip not shown. The anode is inserted over the lip and a cover glass is used.

stances added to uranyl solutions that had been purified by electrolytic or other methods. The results are corrected for blank values, and typical data are given in Table 2.

TABLE 2.—RECOVERIES OF VARIOUS ELEMENTS BY THE PROCEDURE

Element	Amount added	Percent recovered	Method of analysis
	mg.		
Co	0.05	95–100*	Colorimetric
	0.10	95–100*	"
	5.00	97.5	"
Cu	0.05	95–100*	Polarographic
	5.00	103	"
Pb	0.02	about 100*	"
Ni	0.02	95–100*	"
	0.10	95	"
	5.00	98	"
Zn	0.05	95–100*	"
	1.00	98–100*	"
Mo	0.20	None deposited, owing to oxidation-reduction buffering action.	
	1.00		
Cr	1.00	Doubtful. Probably none deposited.	
Mn	1.00	0–2	Colorimetric. In general no Mn is electrolyzed into the mercury.

* Several individual determinations were made.

A superficial investigation was made of the behavior of Bi, In, Tl, Ir, Ru, Ga, Au, Pd, Re, Se, and Te. The first three are quantitatively taken into the mercury. It was not definitely established that the remaining substances can be deposited in the mercury, although Ga, Au, Pd, and Re gave distillation residues that indicated substantial recoveries.

Blanks on reagents.—In routine operation, blanks are run each time a new bottle or other supply of any reagent is introduced. A number of sealed containers of reagents of the same lot are set aside for the work that is planned. A typical set of reagents for handling many types of samples is as follows:

Mercury, 2.5 ml.
Water, distilled, 160–165 ml.
Nitric acid, conc. 6 ml.
Maximum supressor, 0.1 ml.
Sulphuric acid, conc. 5.35 ml.
Hydrochloric acid, conc. 2.1 ml.
Potassium chloride, 25 mg.
Pyridine 0.15 ml.

Successive blanks obtained over a period of several weeks had the following range, in milligrams, Cu, 0.011 to 0.026; Fe, 0.023 to 0.039; Ni, 0.001 to 0.002; and Pb, 0.002 to 0.004.

Cadmium, cobalt, and zinc were not encountered in these reagents. Fluctuations in copper blanks were in one instance traced to a copper pin in an atomizer bulb that was used with a stock bottle of nitric acid. A series of erratic results for cadmium was due to cadmium contained in methanol that was used to wash metallic specimens that were greasy. The cadmium content of the methanol was 2 parts per million. It proved to be unwise to use the polarographic cells and the silica beakers for experiments with major amounts of any of the metals that were being estimated. The iron blank includes additional iron introduced by a succession of reagents that were used in connection with the recovery of iron from the solution that had been electrolyzed.

Calibrations.—Although it was possible to control the composition of the solution that was subjected to polarographic analysis rather rigorously, it was considered desirable to calibrate with mixtures of elements in the normal ranges that were encountered in applying the method. Certain calibrations were made with materials put through the complete process and with proper blank deductions. Other calibrations were made with mixtures of elements taken from standard solutions of their chlorides or nitrates. The solutions were handled in exactly the same fashion as the residues from the distillation of mercury. Perhaps the best evidence that the calibrations were consistent is to be found in the data of Tables 1 and 2. Some of the determinations there reported were on single substances and others were for mixtures of Cd, Cu, Co, Ni, Zn, and Fe in varying ratios.

Reproducibility of the procedure.—A few typical results on the recovery of minor amounts of elements from solutions are shown in Table 3.

Approximately the same degree of reproducibility was obtained in check determinations on numerous samples of various types. A typical example of the polarographic findings is shown in Fig. 2, which presents the polarograms taken from solutions of two equal samples of a slightly alloyed light metal.

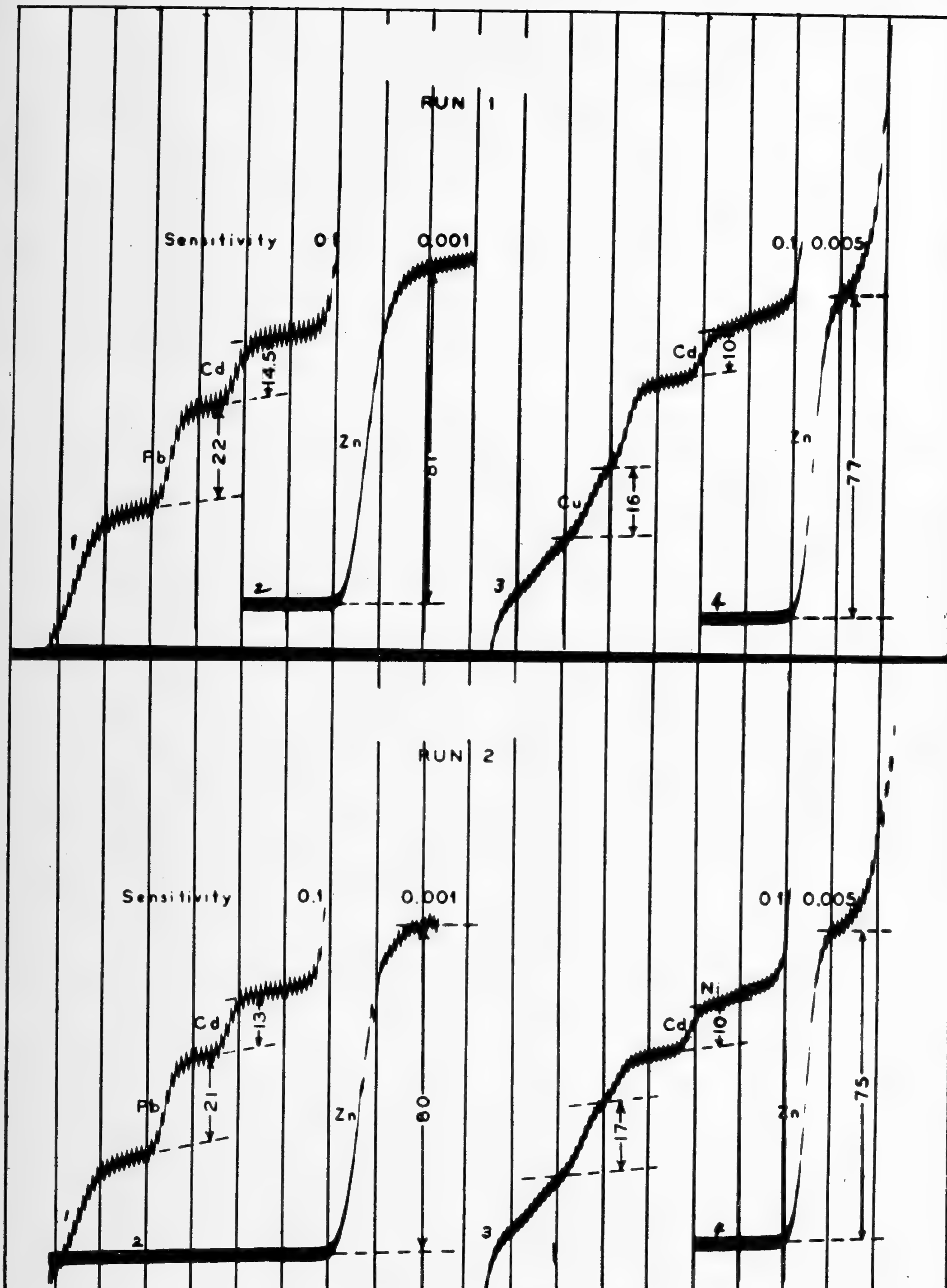

FIG. 2.—Duplicate analyses. Curves 1 and 2 are taken before adding pyridine; curves 3 and 4 after the addition of pyridine. The zinc wave in curve 4 is used for the qualitative estimation of this metal.

OUTLINE OF THE PROCEDURE

A sample is taken of suitable size to give a residue in the range of tenths of a milligram to 2 mg after electrolysis and distillation. The samples may range from a few tenths of a gram up to 20 g or more with the equipment specified. If the material will dissolve in sulphuric acid, an amount calculated to leave 0.5 ml of the free concentrated acid in excess is used. If nitric acid is needed, a measured minimal amount is used. With samples containing much calcium, it is desirable to use hydrochloric acid followed by sulphuric acid and evaporation and fuming to convert to sulphates. Alternatively for samples containing calcium perchloric acid may be used during the solution and electrolysis.

Uranium and its compounds are converted to sulphates, usually after prior treatment such as burning the metal to oxide and treatment with sulphuric acid. It is important to fume off the free sulphuric acid and then to add prior to the electrolysis an amount of free sulphuric acid equivalent to 1 mole of H_2SO_4 per gram atom of uranium because there is an average consumption of 1 mole of acid during the conversion of one gram atom of U^{VI} to U^{III}. Two moles of acid are used up in the reduction from state VI to state IV and one mole of acid is regenerated in the reduction of U^{IV} to U^{III}. If the acidity is not regulated, the recovery of the desired metals may be incomplete. If too little acid is present, hydrolysis may occur during the electrolysis.

A reagent blank has to be carried through with any type of process.

If there is an insoluble residue, it may be filtered and if silica is present, its weight is determined by hydrofluoric acid treatment and the residual oxides are dissolved and added to the filtrate.

Table 3.—Duplicate Analyses of Solutions for Small Amounts of Metals, in Milligrams of Elements Found

	Cadmium	Cobalt	Copper	Iron	Lead	Nickel
1, a.	0.004	0.023	0.029	0.367	0.029	0.005
b.	0.004	0.025	0.026	0.373	0.029	0.005
2, a.	0.001	0.025	0.026	0.620	0.012	0.005
b.	0.000_5	0.014	0.022	0.615	0.012	0.006
3, a.	—	0.018	0.043	0.923	0.009	00.33
b.	—	0.020	0.038	0.918	—	00.30
4, a.	—	0.022	0.059	0.888	0.016	0.015
b.	—	0.023	0.058	0.863	0.010	0.011

Electrolysis.—A 2.5 ml mercury cathode is placed in the cell, Fig. 1, and the solution is added and diluted to 100 ml. A platinum-iridium (10 percent) anode is inserted to a depth of 1.5 cm. A wire of B. and S. gauge 15 (0.058 inch diameter) is satisfactory. The cell is covered with a watch glass. With an applied voltage of 10 volts the series resistance is regulated so that 0.8 ampere flows. This corresponds to an initial cathode current density of about 0.08 ampere per cm^2. At the end of the electrolysis the current has usually dropped to about half the initial value. In order to remove the more active metals such as zinc it is desirable that the cathode potential shall go down well into the region of the lowest soluble oxidation-reduction system that may be present. In the case of uranium it is desirable to have as much trivalent uranium present as possible. Mechanical stirring causes much of the U^{III} to be oxidized to U^{IV} at the anode or at the exposed surface. Such stirring does not interfere with the complete removal of iron. Lead if present in minor amounts goes completely into the cathode when an oxidation-reduction buffer is present. Iron is completely electrolyzed out of solutions that have no oxidation-reduction buffering action. With many types of samples the small mercury cathode is observed to rotate spontaneously at a slow rate that gives a certain desirable amount of agitation near the cathode.

Distillation.—After the electrolysis, which is normally allowed to proceed from late afternoon to the next morning, or from early morning to late afternoon, the mercury cathode is drained into a weighed silica boat, without interrupting the current. The last drop of mercury is caught on a dry filter paper to free it from any trace of solution, and then added to the boat. The aqueous solution is quickly washed into a beaker and the cell is inverted and tapped over a filter paper to recover the last globules of mercury which are blotted dry and added to the boat. If there is as much as a few tenths of a milligram of other metals

present, the mercury has a visible surface scum.

The temperature of the boat is observed during the distillation with the aid of a thermometer inserted through the inlet stopper of the tube furnace. A current of nitrogen, not freed from oxygen, is passed through the furnace during the distillation, and the mercury is condensed in a beaker of water into which the outlet tube dips. As many as three boats at a time are handled in a 12-inch furnace. After distillation the temperature is lowered and when the boat is nearly at room temperature a cylinder of clean paper is inserted in order to avoid contact of the boat with condensed mercury droplets. There is a characteristic change from a golden brown color to bluish with amalgams rich in cadmium and the temperature is lowered as soon as this change becomes evident. If little or no zinc is present and the residue is largely iron it will be distributed in small specks on the bottom of the boat. Zinc and indium form amalgams which are decomposed only at a much higher temperature. The zinc amalgam forms a continuous layer. The weight of the residue is of little significance when zinc is a major component of the residue. Indium was only encountered in synthetic samples.

In residues that contain primarily iron plus very minor amounts of copper, lead, etc., the weight of the residue less the Fe_2O_3, that is equivalent to the iron, agrees fairly closely with the sum of the metals other than iron in about 65–75 percent of the cases. The weight is therefore only a rough index of over-all content of electrolyzable metals. The average ratio of weight of deposit to weight recovered polarographically and colorimetrically in the residue is about 1.88 for a given class of material. The ratio $Fe_2O_3/2Fe$ is 1.43. The discrepancy is in part due to the presence of minor amounts of mercury or platinum and to the fact that the elements other than iron probably are converted more or less completely to oxides.

Solution of the deposit. Polarography.—The boat is placed handle end up in a silica beaker of 150 ml capacity, and the residue is treated with 2 ml of concentrated hydrochloric acid and 1 ml of concentrated nitric acid. The acids are caused to come into contact with all the residue and the covered beaker is heated until solution is complete. The boat is then washed with a minimum amount of water and removed. The solution is evaporated to dryness. Then 0.5 ml of concentrated hydrochloric acid and an aliquot of a potassium chloride solution containing 25 mg of KCl are added and the evaporation is repeated. If mercury is known or suspected to be present, it is volatilized by heating on a hot plate at medium heat. The residue is finally evaporated after the addition of another 0.5 ml of concentrated hydrochloric acid and a little water, at 100°C. The heating is stopped while the odor of HCl is faint but present in the dry residue. This step is very important because sufficient acid remains in the residue to prevent loss of iron or other metals. The residue is dissolved in 2.9 ml of water, and 0.1 ml of 0.1 percent methyl cellulose is added as a maximum supressor. The solution is made homogeneous and as much as possible is transferred to a polarographic cell of the type devised in this laboratory (*10*). The solution is deaerated with nitrogen for 10 minutes, the nitrogen being passed through a purifying train and a wash bottle containing water.

A polarogram is taken at the highest feasible sensitivity, recording that portion of the current voltage curve immediately following the spontaneous initial wave due to iron, etc. In this medium only the cadmium and lead waves are useful. A second polarogram is taken after adding one drop of hydrochloric acid and three drops of pyridine and deaerating for a few minutes; the *p*H of the solution is about 5.2. Lingane and Kerlinger (*4*) proved that the precipitate of hydrated ferric oxide does not carry Cd, Cu, Co, Ni, or Zn. In this second polarogram the copper is determined from the Cu^{I} to Cu^{0} wave and a check is obtained as to the amount of cadmium. The nickel and cobalt waves are well separated, but the cobalt and zinc waves are merged. Iron and cobalt are estimated colorimetrically. If there is a large amount of zinc a third partial polarogram at lower sensitivity has to be taken to get the sum of the zinc and cobalt.

Platinum, if present in the residue from the mercury distillation, is sometimes revealed in the polarogram by a spontaneous rise at the start and an anomalous dip or decrease in current after the lead wave. The dip usually begins to be evident at -0.9 volt applied and reaches a minimum at -1.10 volt applied. The addition of a drop or two of hydrochloric acid eliminates this dip but causes a catalytic hydrogen wave to start at -0.8 volt applied. Platinum may make it difficult or impossible to determine the amount of zinc from the polarogram taken after adding pyridine. The terminal wave is shifted from -1.48 volts to -1.28 volts by 0.01 mg of Pt in 3 ml. With 10 times as much platinum the terminal wave begins at -1.13 volts.

Under the conditions chosen 10 micrograms per 3 ml of any of the common metals Cu, Cd, Pb, Co, Ni, or Zn cause a wave of the order of 1 cm. Under the most favorable conditions 1 microgram of a metal may be detected, provided the metal does not occur in the reagents. If iron is the dominant component of the solution the sensitivity of the detection of lead may be greatly diminished because lead can be detected only in the most acid medium where the sensitivity that may be used is governed by the height of the initial iron wave.

Other determinations.—Systematic procedures have been adapted from colorimetric determinations in the literature for the estimation of iron and cobalt in the solution that has been polarographed. The solution after electrolysis and separation of the electrolyzable metals may be tested systematically for such elements as molybdenum by thiocyanate extraction, after which iron, titanium, and vanadium may be extracted as cupferrates and determined by separate colorimetric tests.

SUMMARY

The possibility of using a small mercury cathode as a collector for minor amounts of electrolyzable metals has been explored and the procedure has been tested for a variety of applications.

A novel combination of techniques based on the distillation of the mercury from the cathode and the polarographic and colorimetric examination of the residue has been devised and studied extensively in a rather limited range of applications. The procedure appears to be capable of many further applications to a great variety of organic or inorganic substances.

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ETHNOLOGY.—*Self-torture in the Blood Indian sun dance.*[1]

John C. Ewers, U. S. National Museum.

When George Catlin, the artist and Indian enthusiast, published (1841) the first graphic account of the practice of self-torture in a Plains Indian ceremony, which he had witnessed in 1832, his description was termed fantastic by D. D. Mitchell, Superintendent of Indian Affairs. Apparently shocked by Catlin's vivid portrayal of coolly premeditated self-sacrifice of human flesh and blood by participants in the Okipa ceremony of the Mandan, Mitchell declared, "The scenes described by Catlin, existed almost entirely in the fertile imagination of that gentleman" (Schoolcraft, vol. 3, p. 254; Catlin, vol. 1. pp. 157–177).

Catlin's description was substantiated, however, some years before Mitchell's accusations were made, by the Independent Mandan investigations of Prince Maximilian in 1833–34, (Maximilian, vol. 23, pp. 324–334). Catlin was defended strongly by the intelligent fur trader James Kipp, who had

[1] Received January 30, 1948.

been with Catlin when he witnessed the ceremony (Kipp, pp. 436–438).

Since the days of that historic controversy, the practice of self-torture in tribal sun-dance ceremonies has been reported, on reliable authority, as once characteristic of the Arapaho, Arikara, Assiniboin, Canadian Dakota, Cheyenne, Crow, Gros Ventres, Hidatsa, Oglala Dakota, Plains Cree, Plains Ojibway, Sarcee, Sisseton Dakota, and the three Blackfoot tribes (Spier, pp. 473–475). Furthermore, brief accounts have been published of ceremonial self-torture, witnessed as early as 1805, among the Arikara and Hidatsa by the fur traders Pierre-Antoine Tabeau and Charles Mackenzie (Tabeau, pp. 191–193; Mackenzie, pp. 354–357).

It seems most probable that some Plains tribes practiced forms of self-torture in the period before first white contact.

Among the Plains Indian tribes of the United States the practice of self-torture was prohibited more than 60 years ago. This ban resulted from the combined opposition of missionaries and the civil and military branches of the Federal Government to such self-imposed cruelties, which tended to excite the Indians, to perpetuate both Indian-white and intertribal hostilities, and to make difficult the process of civilization and Christianization of the Indians.

Published descriptions of self-torture among these tribes have been primarily of two kinds. Some were eye-witness accounts of interested but untrained white observers who not infrequently misinterpreted the purpose of the torture as a ceremony for "making braves." Others were based on the testimony of older Indians who had witnessed the tortures some years earlier but had not experienced torture themselves. Detailed case histories from the mouths of men who had submitted themselves to torture are few and fragmentary in the extensive literature on the sun dance.

Self-torture survived in the sun dances of the Blood and North Blackfoot Indians of southern Alberta for a few years after its discontinuance among the Plains tribes of this country. In the course of field work on the Blood Reserve in September, 1947, the writer met two elderly full-bloods who had been tortured in the sun dance of their tribe. They were the last survivors of men of that tribe who had experienced this ordeal, and they were particularly desirous that their torture experiences should be recorded accurately. These narratives by Scraping White (now 81 years old) and Heavy Head (now 78), related to the writer through the interpreter Percy Creighton, provide new and significant information on the procedure of self-torture in the Blood sun dance ceremony and its meaning to those who submitted to it. They help to round out the only published description of the Blood self-torture, that of the missionary John McLean, who witnessed the ceremony prior to 1889.

In the summer of 1889 the Blood medicine lodge was erected on the north bank of the Kootenay River, in southern Alberta. Three young men, Scraping White (then 23 years of age), Tough Bread (now deceased), and Heavy Head (then 20 years old), presented themselves to be tortured.

Scraping White described his experience thus:

Three of us tortured ourselves in the sun dance that year—Tough Bread, Heavy Head, and I. I was the oldest of the three.

I was on a war party to take horses from the Assiniboine when I made my vow to be tortured. Shortly before the sun went down, when we were in sight of the enemy camp, I turned to the sun and said, "I want good luck. Now I go to the enemy. I want to capture a good horse and go home safely. I'll be tortured this coming sun dance." As soon as it was dark I went into the enemy camp and took two fast horses out of their corral without any of them knowing it. I had good luck and reached home safely.

Then I told my relatives of the vow I had made. Yellow Horn, an older relative, who had been through the torture before, told me, "Put up a sweat lodge for me and I shall look after you." I made the sweat lodge the very next day.

Not long after that the sun dance was held. The torture took place the day after the center pole was raised for the medicine lodge. I was the first one to be tortured. The torture began about noon. Old Yellow Horn cut my breasts with an iron arrowhead and inserted a skewer through the cuts at each breast. These skewers were of serviceberry wood, flattened on both

sides, thinned toward the ends but not sharpened, and about this long. [Scraping White indicated a distance of about 2 inches between his thumb and forefinger.] Then sinew was wrapped around the ends of the skewers and they were tied, each skewer to a 4-strand plaited rawhide rope. The two ropes were fastened at their far ends to the center pole at its forks.

I stood up and Yellow Horn told me, "Now you walk up, put your arms around the center pole and pray. Tell sun, now your vow is being fulfilled." I did just as he told me. Then I stepped back. Yellow Horn pulled hard on the rawhide ropes attached to the skewers. Then I danced. I didn't dance long before my flesh gave way and the skewers pulled out. Yellow Horn came to me and cut the skin that had broken. He trimmed it off even. Then he gave me the pieces of skin he had cut away and told me to take them and stick them in the ground at the base of the center pole, saying, "Now sun, I have completed my vow."

Heavy Head's narrative of his torture experience was still more detailed:

There were only two of us, Buffalo Teeth, my partner, and I. We went to war together to take horses. At Medicine Hat we found a small camp of Cree half-breeds. It was night when we saw their camp. It was moonlight. I looked up at the moon and prayed to it, "I shall be tortured at the sun dance if I have good luck and get home safely." Then I stole up to the camp and got one bay that was tied in front of a lodge without any of the enemy waking or seeing me. Buffalo Teeth took a roan. We started back to the Blood camp, traveled three days and three nights with no food other than a black rabbit. We got awfully weak and hungry.

When I reached home I told my story to my father, Water Bull. The old man got up and sang his encouraging song. Then he told me, "My son, you have done something worth doing. You have made a vow that you will be tortured at the sun dance. You must do it this coming sun dance."

A few days later I went out to the east point of Belly Butte to fast. While I fasted I dreamed that a sacred person came to me and gave me a drum and certain herbs to use for doctoring. Then I returned home.

A short time after that the bands began to come together for the sun dance encampment. I prepared myself to go to an old man named Little Bear, a relative of mine, who had been through the torture himself, years before. I filled my pipe and took it to him. I gave him the pipe and a buckskin horse, and said, "Here is a horse for you. Keep this pipe too. I want you to look after me in the torture." When I gave him the pipe he put it down and went over to the next lodge. There were two old men there, Green Grass Bull and Red Bead. These men were not related to me, but they were both older than Little Bear, and both had been through the torture. Little Bear asked them to come to his lodge, to take my pipe and pray for me. After they prayed, they told me not to take any food or water the day I was to be tortured.

The day before the torture I ate or drank nothing. Next day I ate or drank nothing until after the torture. However, the three old men gave me some sagebrush to chew.

I was the last of the three Blood Indians to undergo the torture that day. Scraping White, who was the oldest, was first. Then Tough Bread, then I. I was the youngest. Inside the medicine lodge, on the west side of the center pole and north of the weather dancer's arbor, a shelter was built of sticks like a sweat lodge, covered with willow leaves. I went in there before noon of the day of the torture. I was laid on my back with my head pointed north. I was barefoot, and wore only a breechcloth made from a small, red, trade shawl purchased from the Hudson's Bay Company. There was a little bowl of white paint and another of black paint nearby. The three old men painted four black dots, one below the other, under each of my eyes. This was called "tear paint." If I cried the tears would run down there. Then they painted a double row of six black dots on each arm. They painted the symbol of the moon, points up, on my forehead in black. On the outside of each of my legs they painted a double row of six black dots. The rest of my body was painted white, also my face. They took some of the broad-leafed sagebrush from the ground inside the sweat lodge and bound it together, placed a wreath of it around my head, and bands of it around each wrist and ankle.

I was taken from the sweat lodge and laid upon a blanket on the ground at the north side of the center pole with my head to the north, my feet toward the center pole. Other people were told to keep back away from me. Then an old man named Low Horn was brought forward. He counted four of his coups. The three old men, Little Bear, Red Bead, and Green Grass Bull, held me—one at each arm, and one at my head. Red Bead took a sharp, iron arrowhead in his hand, and asked me, "How do you want me to cut them? Thick or thin?" I said, "Thin." (I learned later that this question

Fig. 1.—Scraping White (left) and Heavy Head (right), two men who were tortured in the Blood sun dance of 1889.

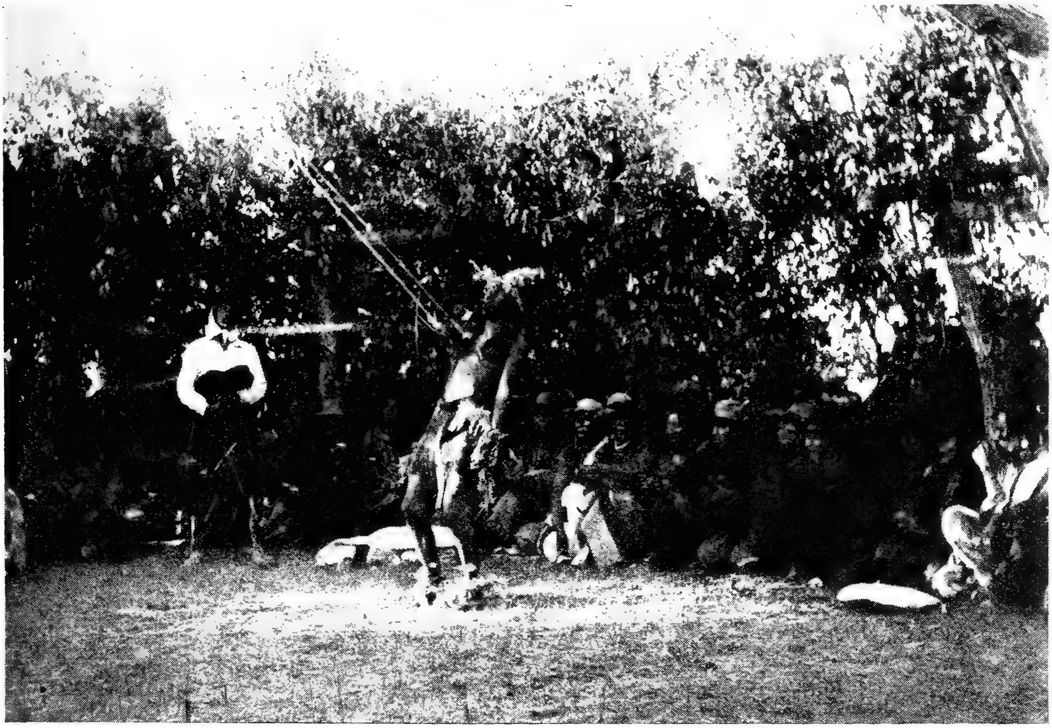

Fig. 2.—An act of self-torture in the Blood sun dance of 1891. Photograph by R. N. Wilson.

was always asked of the man undergoing the torture before his breasts were pierced, and the one doing the cutting always did just the opposite of the young man's request. So when I said "thin," Red Bead knew to make his incisions deep).[2] Red Bead gave four of his own war coups. He made no prayer. Then he pierced my breasts with the sharp arrowhead and inserted a serviceberry stick through each breast. The sticks were not sharp but flattened at the ends. The other two men held my arms as he cut and inserted the sticks. Blood flowed down my chest and legs over the white paint. Then Red Bead pressed the sticks against my body with his hands. They turned me around to face the sun and pierced my back. To the skewers on my back they hung an imitation shield, not so heavy as a war shield. The shield had feathers on it, but I don't remember how it was painted. It belonged to a man named Peninsula.

The ropes were brought out from the center pole and tied to the skewers in my breasts—right side first, then left side. Red Bead then grabbed the ropes and jerked them hard twice. Then he told me, "Now you go to the center pole and pray that your vow will come true." I walked up there. I knew I was supposed to pretend to cry. But oh! I really cried. It hurt so much. Coming back from the center pole I was shouting. Then, before I started to dance, I jerked the shield off my back.

I leaned back and began dancing, facing the center pole. It felt just like the center pole was pulling me toward it. I began to dance from the west toward the doorway of the sun lodge and back. Then, when the skewers did not break loose, the old men realized that the incisions had been made too deep. Red Bead came up and cut the outside of the incisions again so they would break loose. As I started dancing again the left side gave way and I had to continue dancing with only my right side holding. An old man named Strangling Wolf jumped up from the crowd and came toward me shouting. He called out four coups he had counted and jumped on me. The last rope gave way and I fell to the ground.

The three old men came to me and cut the rough pieces of flesh hanging from my breasts off even. They told me to take this flesh that had been trimmed off, and the sagebrush from my head, wrists, and ankles, and place them at the base of the center pole. I did as they told me.

[2] Jenness, pp. 54–5, reported the same contrariness of action on the part of the Sarcee surgeon when the suppliant pleaded for a "thin" cutting.

Then I took my robe and walked out of the medicine lodge alone. I went to a lonely place and fasted for a night. I wanted to dream. But I couldn't sleep at all because of the pain. At sunrise I prayed to the sun.

Some time after that I saw a man approaching on horseback. He said, "I'm going to take you home right away." He took me up behind him on his horse and rode me slowly back to camp. My breasts were swollen and hurt. The rider's name was Red Crane. He told me of a mix-up that took place at the sun dance over horses stolen from the Gros Ventres.

When I got to my lodge, my mother gave me something to eat. She and my father told me what had happened at the sun dance gathering —a mix-up between the Mounted Police and Indians.[3] I had to stay in the lodge several days. My breasts were so swollen I could hardly move. Indian doctors used herb medicines to take the swelling away and cure my wounds.[4]

The common elements in these two accounts reveal the pattern of the self-torture experience among the Blood Indians more clearly and completely than the brief description of the ordeal previously published by McLean. This experience was initiated by a warrior through a vow to the celestial deities, sun or moon (the latter in Blackfoot belief was sun's wife), very shortly before the man exposed himself to danger. The vow was a simple, direct appeal to the deity for protection and success in the immediate, hazardous undertaking. In return for such aid the petitioner promised to make the self-torture sacrifice in the sun dance lodge of his people. On return home after the successful exploit the pledger made known his vow to his relatives. They helped him to obtain the services of one or more older men who had been through the ordeal and were qualified, therefore, to instruct and care for the young man in the ceremonial fulfillment of his vow. The public cere-

[3] In the summer of 1889, the Mounted Police sought to apprehend Calf Robe, a Blood horse thief, who sought sanctuary in the medicine lodge of his people. The Indians overpowered the police and set Calf Robe free, but there was no bloodshed (Steele, pp. 262–265). This incident serves to verify the year of Scraping White's and Heavy Head's torture.

[4] These narratives follow as closely as possible the words of the interpreter. In a few places details obtained during further questioning of the informants have been inserted.

mony took place in the sun-dance lodge, about midday of the day following the erection of the center pole. One man was tortured at a time. Each young man's experienced helper or helpers prepared him for the ordeal, pierced his breasts, inserted the wooden skewers, and attached the thongs leading from the crotch of the center pole. They guided his actions by telling him first to embrace the center pole and pray for successful fulfillment of his vow, watched him closely until he freed himself from the ropes, trimmed off the ragged edges of flesh from his breasts and instructed him to place them at the base of the center pole as an offering to the sun. With this act the vow was fulfilled.

Both informants stated that the helpers were always men well advanced in years, rather than men who had been through the torture only a few years earlier. The number of helpers depended primarily on the age of the victim and his relative's confidence in his ability to take the punishment. Younger men generally had more helpers to hold them as the incisions were made. Fasting was not considered obligatory. Scraping White said he was not required to abstain from food on the day prior to the torture. Scraping White's narrative omits mention of the painting of his body in preparation for the torture. However, Heavy Head asserted that all who underwent the torture were painted just as he had been.

Neither Scraping White nor Heavy Head took any active part in the tortures at the sun dance of 1891, the last occurrence of self-torture in the Blood ceremony. They said that four men, Calf Tail, Buckskin Tom, Old Man Owl, and Takes Paint, all now deceased, were tortured in that year. R. N. Wilson, a trader on the Blood Reserve, photographed these torture ceremonies. One of his photographs is reproduced here, through the courtesy of Archdeacon S. H. Middleton, principal of St. Paul's Residential School, on the Blood Reserve, owner of a print from the original glass plate negative. Percy Creighton believed that the Indian shown in the act of torture was Takes Paint.

The Blood Indians were the last Blackfoot tribe, and probably the last tribe of Plains Indians to observe the self-torture ceremony. After their 1891 performance of the torture it was prohibited by the Indian Department and the Mounted Police. A year earlier the North Blackfoot had been persuaded to abandon torture (Ann. Rept., pp. 83–84). The Piegan eliminated torture from their sun dances at least 20 years earlier. Weasel Head (born about 1860), for many years a prominent weather dancer in the South Piegan sun dance, told the writer before his death in 1943, that he had never seen the torture performed in the sun dance of his tribe, although he recalled that as a youth he had seen older men who bore the scars of torture. Red Plume (born ante 1850), informed Curtis that he had seen the torture rites in the Piegan sun dance only four times, thrice when a small boy and once when a young man. Each time a single man had submitted to the torture. Red Plume attributed the discontinuance of self-torture in the Piegan sun dance to the warning of a North Piegan weather dancer that "they would die if they gave their bodies to the sun" (Curtis, vol. 6, p. 55). Clark Wissler (p. 262) and Walter McClintock (p. 320) reported the persistence of this belief among the Piegan in the first decade of the present century.

Wissler (p. 263) believed that self-torture had not become thoroughly adjusted to its place in the Piegan sun-dance ceremony at the time it was abandoned. On the other hand, the torture appears to have found much more favor among the neighboring Blood Indians. McLean (p. 236), stated that from two to five men underwent this torture every year in the Blood sun dance. Whereas the Piegan seem to have abandoned torture as a result of native fear and distaste for the ceremony, the Blood continued to practice it until they were compelled by Government authorities to give it up.

Wissler (pp. 263–264) was inclined to credit a Piegan tradition that the Blackfoot tribes borrowed the torture ceremony from the Arapaho. There still exist among the Piegan vague but persistent traditions of a group of Blood Indians who sojourned for a number of years with the Arapaho in the early part of the nineteenth century. Chey-

enne traditions, obtained from elderly men of the Southern Cheyenne nearly half a century ago by George Bird Grinnell and George E. Hyde, tell of a group of Gros Ventres and "Blackfeet" (division not indicated), who joined the Cheyenne and Arapaho in the Black Hills or on the Platte about the year 1826. According to one version of this tradition the "Blackfeet" returned north a few years later (Grinnell, vol. 1, pp. 39–40). Major Culbertson, who was married to a Blood woman, is reported to have found ten lodges of Blood Indians living with the Arapaho, when he attended the Fort Laramie Treaty Council in 1851. "They were unknown to him, and he did not learn how long they had been there or whether they ever returned" (Bradley, Book A, p. 184). These data, and the fact that the Piegan were relatively indifferent to the torture in later years, suggest the possibility that the torture feature was introduced among the Blackfoot tribes by Blood Indians, who may have borrowed it from the Arapaho no earlier than the second quarter of the nineteenth century.

Spier (p. 491) regarded the self-torture as a nonessential element in the sun-dance ceremony of most Plains tribes. Our evidence certainly supports this conclusion insofar as the Blood sun dance is concerned. Both the torture pledger and his helpers played no necessary part in the sun-dance ceremony. They entered the medicine lodge for the sole purpose of fulfilling the pledger's vow. The Blackfoot tribes have continued their annual sun dances to the present day, with no apparent sense of loss of any essential feature. Now as formerly the sun dance centers about the elaborate ritual prescribed for the fulfillment of the vow of the medicine woman who pledged the ceremony. Her objective was reached with the completion of the medicine lodge, the day before the tortures took place.

The Blackfoot tribes regarded the torture, such as was endured by Scraping White and Heavy Head, as the most dangerous and severe form of physical sacrifice to the sun. The mutilation of the body by offerings of a finger or bits of flesh from the arms and legs were considered lesser ordeals (Wissler, pp. 263–265). Scraping White showed the writer scars on his legs resulting from the sacrifice of pieces of flesh to the sun prior to the year of his torture experience. Nevertheless, the belief of the Piegan that men who submitted to the torture would not live long after they had given their bodies to the sun, appears to have been based upon religious fear rather than the life histories of men who had been tortured. Several of our elderly South Piegan informants recalled having seen older men of the tribe who bore the scars of the torture. The severity of the torture varied with the depth of the incisions. Older men watched the suppliant carefully, and did not permit the torture to be prolonged indefinitely. Even in the case of Heavy Head, whose experience was described by other elderly Blood Indians as the most severe punishment they had witnessed in sun-dance tortures, the performance lasted only a few minutes. His narrative indicates the pain and nervous shock must have been intense. But in the majority of cases it probably did no permanent damage to the individual. Although Scraping White and Heavy Head still bear the scars of their torture, these men appear to be in fair health, active of mind and body, nearly six decades after they expiated their vows to the sun in the Blood medicine lodge in the summer of 1889.

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PALEONTOLOGY.—*On two previously unreported selachians from the Upper Cretaceous of North America.*[1] David H. Dunkle, U. S. National Museum. (Communicated by C. Lewis Gazin.)

Recently, the U. S. Geological Survey transferred to the National Museum two interesting toothlike fossils obtained by Dr. L. W. Stephenson during the course of his prolonged geological investigations on the Cretaceous formations of Texas. These specimens have proved to be examples of the structures currently interpreted as rostral teeth of pristid sharks. They are assignable to the genera *Onchopristis* Stromer and *Schizorhiza* Weiler, both of which were founded on materials from various upper Cretaceous horizons and localities in North Africa. In the Western Hemisphere, *Onchopristis* has not heretofore been known and *Schizorhiza* only from a single, doubtful report from the upper Senonian of Chile (Wetzel, 1930; and Weiler, 1930).

The definitive record of the fossil Pristidae in North America is confined to the isolated rostral armament of *Pristis* from the Cretaceous and a number of Tertiary horizons. In addition, during recent years the problematical genus *Ischyrhiza* has been included here. In the Eastern Hemisphere no less than 12 genera of fossil pristids are recognized. The majority of these are founded on isolated rostral teeth and their assignment to the family Pristidae, oftentimes doubtfully, has been based on the nature of their insertion onto the rostral cartilages as shown by gross morphological features and by histological considerations.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 30, 1948.

The present two specimens can not lend themselves to histological preparation without destruction, and little of general morphological and systematic information can be deduced from them. However, the new occurrences in essential stratigraphic contemporaneity with their North African genotypes seems of sufficient interest to warrant the following brief description.

The illustrations accompanying this note have been prepared by Mrs. Elinor Stromberg, scientific illustrator of the U. S. Geological Survey.

Onchopristis cf. **numidus** (Haug)

A single unassociated tooth (U.S.N.M. no. 17088), although with only one side exposed and lacking the distal extremity, exhibits well the characteristics of the genus as defined by Stromer (1917).

The structure is strongly compressed, dorsoventrally, and is composed of a short inserted base and an exposed, enamel-covered crown. The line of demarcation between these two parts is prominent, being remarked by a constriction of the base adjacent to the proximal limit of the enamel. This latter shows a border arched in gentle convexity toward the base and extended obliquely across the long axis of the element. The preserved portion of the crown possesses one posterior barb. Both anterior and posterior margins of the crown form sharp cutting edges except at the proximal reentrance of the barb where the edge is bluntly rounded. The enamel on the slightly convex, exposed surface of the tooth is checked both

Fig. 1.—*Onchopristis* cf. *numidus* (Haug) (U.S.N.M. no. 17088). Rostral tooth from the Woodbine formation of Texas. Approx. ×4.

longitudinally and transversely as a result of weathering but exhibits no observable ornamentation. The base, in dorsoventral aspect, is expanded and is marked by a few regularly spaced furrows, which are extended in the direction of the longest axis of the tooth.

Measured in relation to the longest axis, the specimen has the following dimensions: Total preserved length, 13.7 mm; greatest length of base, 4.5 mm; maximum width of base, 8.4 mm; width of crown immediately below barb, 6.0 mm; and greatest thickness of crown on fractured distal exposure, 2.4 mm.

Remarks.—The systematic history of *Onchopristis numidus* (Haug) has been completely summarized by Stromer (1917). The present example from Texas differs from the North African specimens in the shortness of that portion of the enameled crown proximal to the barb. Stromer (1917, 1925, and 1927), however, in his discussions on this sawfish, has demonstrated wide variation between individual rostral teeth and has described examples with multiple posterior barbs. In consequence there seems to be no immediate basis for erecting additional species within the genus.

Geological horizon and locality.—Collected from the Upper Cretaceous (Cenomanian) in the Lewisville member of the Woodbine formation, approximately 2.4 miles southwest of Lewisville, Denton County, Tex., by L. W. Stephenson, October 25, 1945.

Distribution.—All the North African occurrences of *Onchopristis* are considered by Stromer to be of Cenomanian Age.

Schizorhiza cf. **weileri** Serra

To this form is assigned a small imperfectly preserved tooth (U.S.N.M. no. 17087). The complete outline of one side of the specimen is clearly impressed in the limy sandstone matrix, although almost all the tooth tissue from that side has been lost. The opposite side of the tooth is deeply imbedded in the matrix of the counterpart. As thus incompletely exposed it was necessary to crack the counterpart in two and examine the cross section of the imbedded part before any structural interpretation could be made.

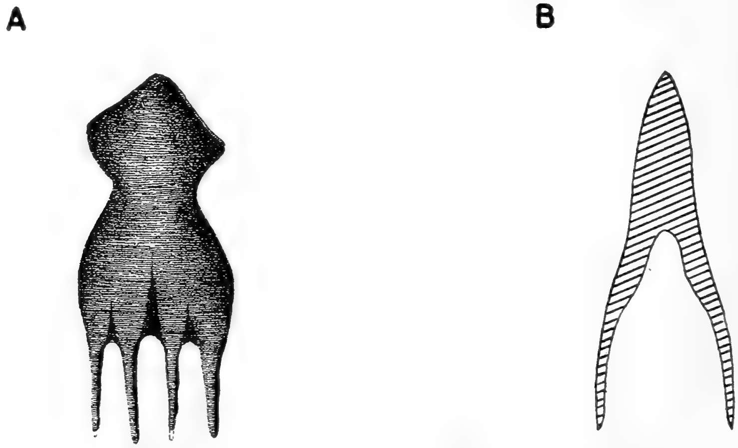

Fig. 2.—*Schizorhiza* cf. *weileri* Serra (U.S.N.M. no. 17087). Rostral tooth from the Escondido formation of Texas in (*A*) dorsoventral aspect as restored from a cast of the preserved impression and in (*B*) ideal transverse section. Approx. ×4.

It is assumed that this tooth projected laterally from firm attachment along the edge of a rostrum. In orientation, therefore, the long axis of the tooth is a transverse dimension, and this breadth exceeds the shorter length by about three times. The element is moderately compressed, dorsoventrally, and the top and bottom halves are apparently symmetrical. The crown occupies approximately one-third the longest axial dimension, and from the shiny smoothness of its impression is indicated to have been enamelled. It projects directly out in the frontal plane of the tooth without dorsad or ventrad flexure; is arched very slightly toward the rear; and is basally emarginated at the anterior and posterior edges. The free lateral margins are sharp, straight, and converge to an obtuse distal point. The root, viewed either dorsally or ventrally, is seen to expand proximally from a narrow distal neck. The part is divided into flat upper and lower lips by a frontal groove which extends outward nearly to the base of the crown. Three furrows traverse the outer surfaces of both upper and lower lips, parallel to the long axis of the element. These grooves are continued proximally as deep notches in the inner edges of the root lips. Thus, mesially, the lips are each produced into four acutely conical projections, of which the central two are the longest.

Measured in relation to the longest axis, the tooth possesses the following dimensions: Total length 15.0 mm; length of crown, 4.0 mm; maximum width of crown, 5.0 mm; maximum width of root, 6.0 mm; length of longer proximal rays, 5.5 mm; and depth of proximal divergence of root lips, 6 mm.

Remarks.—The genus *Schizorhiza* is known only from isolated teeth and the genotype is the species *stromeri* (Weiler, 1930). In addition to some Egyptian specimens, Weiler included in his original description a number of fragmentary teeth from several widely scattered localities (Di Stephano, 1919; Quaas, 1902; and Wetzel, 1930). This type series presented a range of structural variation from teeth as here described to examples which in gross features appear similar to *Ischyrhiza*, with long tapering, scimiterlike crowns and robust roots exhibiting only a shallow frontal groove. Apparently no one specimen among those was designated the type. Subsequently, Serra (1933) abandoned the name *stromeri* for all of the teeth of the type series except that pictured by Weiler in his Fig. 1a, Pl. II. In return, the specific name *weileri* was proposed for the tooth illustrated as Fig. 3a, Pl. II, and a collection of identical specimens from Sofeggin, Tripolitania.

Of these two species, the present Texas specimen is more closely comparable with *weileri.* It differs from it only in the more pronounced asymmetry of the crown profile in dorsoventral aspect and in exhibiting a greater size than reported by Serra. Provisional assignment to the latter species is therefore made. While possibly representing a new species, it does not seem advisable to establish a type on this, an incomplete tooth heretofore unrecorded from North America. A more critical evaluation will depend upon the acquisition of a series of the Texas specimens which permit qualitative studies and histological examination.

Geological horizon and locality.—Collected from the Upper Cretaceous (Maestrichtian) in the Escondido formation, 2 miles east of Eagle Pass, Maverick County, Tex., by L. W. Stephenson, October 30, 1912.

Distribution.—Weiler (1930) gave a Senonian Age to all the teeth from North Africa, Arabia, and Chile on which he based his definition of *Schizorhiza stromeri* (*sensu lato*). Serra (1933) considered the occurrence of *S. weileri* as Maestrichtian.

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ENTOMOLOGY.—*Synoptic revision of the United States scarab beetles of the subfamily Dynastinae, No. 4: Tribes Oryctini (part), Dynastini, and Phileurini.*[1]

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This paper is the fourth in the series of my United States dynastine scarab beetle studies and completes the specific listings and notes. The fifth, and last, part will include a complete classification of the tribes and genera, from the Nearctic standpoint.

Genus **Aphonus** LeConte

Aphonus LeConte, 1856, p. 21; Horn, 1882, p. 122; LeConte and Horn, 1883, p. 259; Casey, 1915, pp. 178, 210; Ritcher, 1944, p. 28, Cartwright, 1944, p. 36.

Podalgus (part) Burmeister, 1847, p. 117; Lacordaire, 1856, p. 408.

Aphonus (as now constituted) is limited to the Eastern United States and contains four valid species; the farthest west I have knowledge of the genus occurring is Texas, where *brevicruris* Cartwright was collected.

The only character separating the adults of *Aphonus* from United States species of *Cheiroplatys* Hope is the trilobed (varying to subtridentate to even simply carinate in worn examples) preapical carina of the clypeus. In the larvae, Ritcher has pointed out (1944) the very close similarity between *Cheiroplatys pyriformis* LeConte and *Aphonus castaneus* (Melsheimer), the only real difference being that the first antennal segment in the latter is bare of setae, and the other two key characters being those of degree only (relative distance between lobes of the thoracic spiracle, respiratory plate, and width of the head capsule). In the adults, the peculiar preapical carina and the rather odd apical, front tibial tooth, as well as external facies and proportions in general, immediately disclose the close affinity of the two groups at present called *Aphonus* and *Cheiroplatys*. Indeed, I have relatively fresh specimens of *A. castaneus* (from Massachusetts and New Hampshire) in which the preapical clypeal carina is distinctly *bidentate*, so that the only character for the retention of the name *Aphonus* as a valid genus is gone.

However, even though I feel that *Aphonus* must eventually be considered a synonym of the earlier described *Cheiroplatys* I am unable definitely to synonymize the two genera until I can review the genotypes; I desire also to dissect carefully the mouthparts of many of the Neotropical and Australian forms of the genus.

The sexes of *Aphonus* are rather similar in most characters, but in the male the last abdominal sternite is shorter and is feebly but distinctly emarginate apically, whereas the last abdominal in the female is longer and the apex is evenly rounded.

I have been unable to construct a satisfactory key to the species based on nonvariable external differences, so that to place the species properly it is necessary to make genital dissections. The only general statement that can be made as to the external facies is that *castaneus* is most frequently rufous, averages 10 to 11 mm in length, and is more robust; whereas *densicauda* and *tridentata* are both more elongate, and the former averages 13 mm in length and the latter 15 mm. Obviously, such generalities are interesting but of little assistance in actually separating closely allied and variable species. According to Cartwright's description of *brevicruris* (the unique type of which I have not seen) the proportions of the heavy, short tibia and femora will readily separate this species from all other described forms.

[1] Received September 3, 1947.

Aphonus castaneus (Melsheimer)
Fig. 1, *k*, *m*

Bothynus castaneus Melsheimer, 1856, p. 138; LeConte, 1856, p. 22.
Podalgus obesus Burmeister, 1847, p. 119; Arrow, 1909, p. 341.
Aphonus castaneus (Melsheimer) Casey, 1915, p. 220; Sims, 1934, p. 334 (larvae); Johnson, 1942, p. 79; Ritcher, 1944, p. 30, pls. 2–5 (larvae).
Aphonus cubiformis Casey, 1915, p. 221.
Aphonus saginatus Casey, 1915, p. 220.
Aphonus trapezicollis Casey, 1915, p. 219.

All examples of this small species that I have examined vary from rufocastaneous to piceocastaneous in color, and from 8 to 13 mm in length. The species ranges generally along the East Coast from Maine south through the Carolinas, Georgia, and Alabama. Johnson mentions finding numerous larvae on the surface of a Connecticut golf course during a gentle July rain, and these larvae retreated into the sod when the sun reappeared. Sims records the larvae as common in the turf of the coastal plains golf courses and in sandy soil generally.

Aphonus densicauda Casey
Fig. 1, *h*, *l*

Aphonus densicauda Casey, 1915, p. 216; Ritcher, p. 31 (larvae).

Described from Pennsylvania, and seen also from New Hampshire, south to Georgia and Kentucky and west to Iowa; will probably be found to have a much wider distribution than indicated by available specimens. Ritcher records it as fairly common in Kentucky where full-grown larvae may be found in pastureland, in or just beneath the sod, from November to May, and pupation occurs late in May or early in June; he found adults in the soil throughout the year.

The color is usually piceous or piceocastaneous, varying to rufous, as do all species of the genus, and the length averages 13 mm. The adults are hard to separate from typically black *tridentatus* other than on genital characters and the slightly larger average size of the latter (15 mm.); the larvae are also very similar but distinct according to Ritcher (1944).

Aphonus tridentatus (Say)
Fig. 1, *f*, *i*, *j*, *n*

Scarabaeus tridentatus Say, 1823, p. 209.
Bothynus variolosus LeConte, 1848, p. 88 (new synonymy).
Aphonus tridentatus (Say) Horn, 1882, p. 122; Casey, 1915, p. 215; Ritcher 1944, p. 33 (larvae); Arrow, 1937, p. 42 (additional refs.).
Aphonus aterrimus Casey, 1915, p. 216.
Aphonus congestus Casey, 1915, p. 218.
Aphonus elongatus Casey, 1915, p. 215.
Aphonus frater LeConte, 1856, p. 22.
Aphonus hydropicus LeConte, 1856, p. 22.
Aphonus ingens Casey, 1924, p. 334.
Aphonus modulatus Casey, 1915, p. 219.
Aphonus politus Casey, 1915, p. 218.
Aphonus scutellaris Casey, 1924, p. 335.

Usually piceous, this largest United States species of the genus varies to entirely rufous, especially in specimens from Florida, and these latter are the *variolosus* of LeConte; the Florida specimens are often 2–3 mm smaller than the more northern specimens and superficially look different, but the genitalia and all essential diagnostic characters are identical and I have no doubt of the correctness of the synonymy. I have seen specimens from Michigan, Indiana, Illinois, south through Georgia, South Carolina, and Florida; also recorded from New York and Wisconsin. Cartwright has taken numbers at Clemson, S. C., from March through July. Ritcher says that the larvae are found in woodland loam; collected by Yeager from "forest duff" in Michigan.

Aphonus brevicruris Cartwright
Fig. 1, *e*

Aphonus brevicruris Cartwright, 1944, p. 36, pl. 1, fig. 5.

Described from a unique male collected at Austwell, Tex., May 20, 1941 (Goodpaster collector), and not taken since to my knowledge. I have not seen the type, and the information here is reworded and taken from Cartwright's paper: Easily separable from all other United States species by the proportions of the hind legs: the femur is three-fifths as wide as it is long, the tibia is *shorter* than the femur, and the tibial apex is widely flared and *more than* half as wide at apex as the full tibial length; in all other United States species the hind femur is only *half* as wide as long, the hind tibia and femur are *subequal* in length and the hind tibial apex is flared but at most is one-third as wide at apex as the length.

Tribe Dynastini

Some of the largest and heaviest insects in the world occur in this tribe, including

the well-known *Dynastes hercules* of the American Tropics. Arrow (1937) lists only 21 genera in the tribe from the world, many of these genera being monobasic. The essential character of the enlarged male forelegs is not too well shown in our United States species, but in our relatively common *Golofa* Hope and such *Megasoma* as *elephas* the character is strongly indicated. In the Colombian *Golofa porteri* Hope the front legs in the male are as long as the entire body and exactly twice as long as the forelegs of the females. Bates (1889) reports the immense *Megasoma elephas* (Fabricius) as feeding in numbers on ripe mangoes in Panama, and my father has collected numbers around street lights in central Panama, where the large lumbering insects often fly into the faces of passersby and occasionally badly scratch or at least scare them! Since a large male specimen weighs nearly half a pound, the bruises and abrasions that could be occasioned by such a specimen flying into a person's face is easily imaginable.

We have only two genera in the United States.

KEY TO UNITED STATES GENERA

First segment of hind tarsus sharp on outer side but not really extended into a long spine (length of segment on *outer* side exclusive of apical movable setae only one-third to one-fifth longer than length on *inner* side); prosternal spine high between front coxae (as "tall" as its own width across base) and always either densely hairy or at least hairy or setose apically on posterior side; surface glabrous and usually gray, speckled with piceous spots (rarely unicolorous in some females); male with front thoracic angles normal, that is, not sinuous (southeast and southern United States and Mexico) .... *Dynastes* Kirby

First segment of hind tarsus with a long distinct apical spine (length of segment on outside, including spine, one-half to three-fourths times longer than length on inner side); prosternal spine much shorter than coxal length (two-thirds as "tall" as its own width across base) and always quite glabrous on external face; surface always hairy (velvety) and unicolorous piceous; male with each front thoracic horn strongly sinuous (Arizona and Mexico) .... *Megasoma* Kirby

Genus **Dynastes** Kirby

Dynastes Kirby, 1825, p. 568; Burmeister, 1847, p. 256; Lacordaire, 1856, p. 444; Casey, 1915, p. 258; Arrow, 1937 (many references given), p. 95; Ritcher, 1944, p. 39 (larvae).

Our species have been variously listed or described in the genera *Scarabaeus*, *Geotrupes*, *Xylotrupes*, and others by the older authors and such references are readily available in Arrow (1937) and Burmeister (1847).

Arrow lists 13 species of these so-called "rhinoceros beetles" as valid in his 1937 catalogue, these occurring in India, the Philippines, Java, Burma, Borneo, Nigeria, the Congo, and the Americas. I seriously doubt that all these could possibly be congeneric. At any rate, six species are listed from the Americas, and two of these are supposed to occur in the United States. The large and well-known *hercules* apparently has not been taken yet north of Guatemala, except possibly in quarantine interceptions, and it appears to be replaced in Mexico by the much smaller so-called *hyllus* of Chevrolat. I have seen specimens of the latter species from central and southern Mexico and am entirely unable to separate them either on genital or external characters from our common *tityus* (Linnaeus).

Our Arizona *Dynastes* are usually called *granti* Horn; the male genital characters are *identical* with those of *tityus* and the only differences can be summed up in the following (the thoracic horn is measured with a micrometer scale in a direct line between the laterobasal denticles at each side of the horn base, and the horn apex):

Male thoracic horn *distinctly* 6–8 times *longer* than scutellar length (19–23 mm/3 mm); this horn also much broader basally through the denticles; horn on head long, with a very distinct and large, preapical tooth on the dorsal side (Arizona) .... *granti* Horn

Male thoracic horn 3–5 times longer than scutellar length (7–12 mm/2.5 mm); horn of head usually *faintly* notched dorsally or entirely smooth, never with a dorsal preapical tooth. Eastern United States and Mexico .... *tityus* (Linnaeus)

As anyone who has worked to any extent in the Dynastini knows, these characters as listed above are highly variable in a group where exceptionally dimorphic forms are the rule rather than the exception, and I am not at all sure of the validity of *granti*. We have an exact counterpart of this in the related and well-known *Golofa imperialis* Thomson and *pizarro* Hope where the males are unusually variable and the thoracic horn in *male majors* is unusually long and toothed within, varying through all degrees to the *male minors*, in which the horn is

the merest sort of a knob with a smooth inner surface. Until such time as exact intermediate specimens can be collected between Arizona and the more typically eastern *tityus*, it appears best to retain the name *granti* as a weak subspecies of *tityus*.

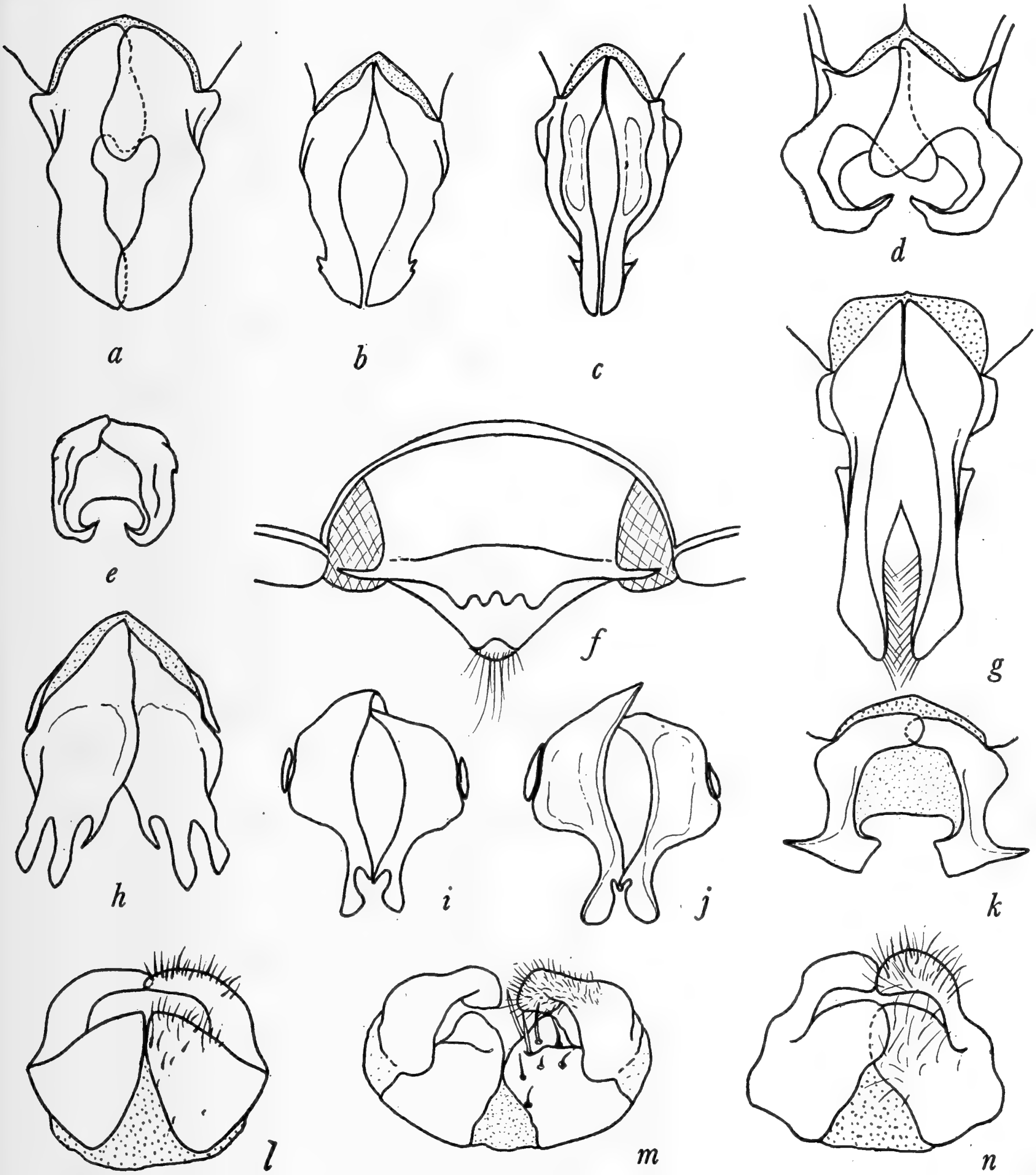

FIG. 1.—*a*, *Phileurus truncatus* (Beauvois): Male genitalia; *b*, *Archophileurus cribrosus* (LeConte): Male genitalia; *c*, *Phileurus illatus* LeConte: Male genitalia; *d*, *Phileurus castaneus* Haldeman: Male genitalia; *e*, *Aphonus brevicruris* Cartwright: Male genitalia; *f*, *Aphonus tridentatus* (Say): Head of female, front view; *g*, *Dynastes tityus* (Linnaeus): Male genitalia; *h*, *Aphonus densicauda* Casey: Male genitalia; *i*, *Aphonus tridentatus* (Say): Male genitalia, from Jacksonville, Fla.; *j*, *Aphonus tridentatus* (Say): Male genitalia, from South Carolina; *k*, *Aphonus castaneus* (Melsheimer); Male genitalia; from Rhode Island; *l*, *Aphonus densicauda* Casey: Female genitalia; *m*, *Aphonus castaneus* (Melsheimer): Female genitalia; *n*, *Aphonus tridentatus* (Say): Female genitalia.

Dynastes tityus (Linnaeus)
Fig. 1, *g*

Scarabaeus tityus Linnaeus, 1763, p. 391.
Scarabaeus marianus Linnaeus, 1767, p. 549.
Scarabaeus pennsylvanicus DeGeer, 1774, p. 308.
Scarabaeus hyllus Chevrolat, 1843, p. 33 (new synonymy); Bates, 1888 (as *Dynastes*), p. 336; Dugès, 1887 (as *Dynastes*), p. 137 (biology).
Scarabaeus iphiclus (Panzer) Burmeister, 1847, p. 259.
Dynastes tityus (Linnaeus) Burmeister, 1847, p. 260; Lacordaire, 1856, p. 444; Arrow, 1937, p. 98 (many references); Casey, 1915, p. 260; Hamilton, 1886, p. 112 (biology); Manee, 1915, p. 266 (biology); Ritcher, 1944, p. 39 (larvae).
Dynastes corniger Sternberg, 1910, p. 26 (new synonomy).
Subspecies: *Dynastes granti* Horn, 1870, p. 78; Casey, 1915, p. 261; Arrow, 1937, p. 97.

This large and familiar species is widespread throughout the eastern United States from New York and Pennsylvania south through Florida, west to Arizona and south into Mexico, and possibly Guatemala. Varies greatly in size and color, especially in the females. The smallest specimen I have seen was 37 mm and the largest 74 mm; with the average about 55 mm. The often asymmetrical (bilateral) coloration has been frequently noted, especially in the females, and a good description is given by Ritcher (1944) of this variation in adults he collected in a single stump and very probably from a single parent: in 14 pupal cells (7 males, 7 females), 8 individuals were spotted, 5 had one elytron spotted and the other of a solid dark mahogany color, and 1 was of a uniform dark mahogany color. The larvae are recorded as feeding in decaying wood of oaks, pines, chestnut, willows, wild cherries, black locust, and fruit trees such as peaches and apples. The adults feed on the sap of wounded trees as well as decaying fruit of peaches, plums, pears, and apples, and Casey claims that the adults have a characteristic odor that can be smelled for some distance, if the observer is downwind of a considerable number of individuals.

D. granti Horn was described from Arizona, though *tityus* has also been recorded from this State. As stated above, I am not at all sure that the form is sufficiently distinct to warrant its retention.

Genus **Megasoma** Kirby

Megasoma Kirby, 1825, p. 566; LeConte and Horn, 1883, p. 260; Casey, 1915, p. 261; Arrow, 1937, p. 98 (other references).
Megasominus Casey, 1915, p. 261; Arrow, 1937, p. 35.
Megalosoma Burmeister, 1847, p. 273.
Lycophontes Bruch, 1910, p. 73.

Arrow lists eight species of this American genus, five of them from South America. Our only species in the United States is the *thersites* of LeConte, which occurs in Arizona and Lower California. Casey erected the genus *Megasominus* for this species, the essential differences between it and the very much larger Neotropical *elephas* (Fabricius) being the presence of a large basal horn dorsally on the base of the male cephalic horn in the latter, and also the marked sexual dimorphism in the front legs of the two sexes of *elephas* (fore tibia of male noticeably elongated and curved, and not so in female); in *thersites* there is no trace of a dorsal tooth on the base of the large cephalic horn, nor is there any difference between the length of the front legs in the two sexes. At first glance, there is a marked difference between male *elephas* and *thersites:* the former is very large ($3\frac{1}{2}$ to $4\frac{1}{2}$ inches) and with a dense uniform clothing of short velvety pile, and a very large forward-projecting tooth on the base of the cephalic horn, and the mid-disc of the thorax is evenly convex without a central horn; whereas in *thersites* the male is small ($1\frac{1}{4}$ to $1\frac{1}{2}$ inches long), the cephalic horn has no basal tooth, the dorsal clothing of pile is slightly longer, less velvety, and much less uniformly placed, and the mid-disc of the thorax has a narrow, semierect horn, which is slightly bifurcate apically. However, in the females of the two species, the only essential difference besides size is that the thorax base in *elephas* is strongly margined, as opposed to the nonmargined base of *thersites*, but all other essential characters are so closely similar that it is necessary to treat the two species as congeneric.

Megasoma thersites LeConte

Megasoma thersites LeConte, p. 336.
Megasominus thersites (LeConte) Casey, 1915, p. 259.

This uncommon species is usually confined to Lower California, but I have a specimen taken in the "Coyote Mts., Arizona, August, 3,500 ft. elevation." Ross and Bohart collected the species at San Venancio in Lower California on October 8, 1941. Easily separable in the male from all other United States Dynas-

tini by the combination of the strongly bifurcate clypeal horn, and the sharp tooth of each front thoracic angle, as well as the moderate to short, narrow, erect, weakly bifurcate horn of the mid-disc of the thorax. The female is readily separable from female *Strategus* by the *widely separated* front teeth on the apex of the clypeus (one at each side angle) as well as the sharp, bidentate mandibles and the non-margined center base of the thorax. The female *thersites* somewhat resembles a female *Aphonides dunnianus*, but the clypeus there is unidentate at apex and the mandibles are equally rounded and not at all toothed. The life history is apparently unknown.

It is very surprising to me that the male aedeagus of this species is inseparable in form from that of male *Dynastes tityus*, but such appears to be the case, based on my own careful dissections; throughout dynastines generally, the characters of the male genitalia appear to be specific within narrow boundaries of variation.

Tribe Phileurini

This tribe is the most aberrant of the subfamily Dynastinae, as the labial palpi are inserted on the *underside* of the ligular plate instead of *at the sides*, and the generally black color and the depressed (majority of species) dorsal surface is suggestive of the Passalidae. Numerous genera and species are described and the tribe is world-wide; our American (Neotropical) species and genera are very poorly and inadequately known.

The two sexes are not well differentiated externally in this tribe. The only obvious external sexual difference is that the male sixth abdominal sternite (instead of being emarginate apically as in most other dynastine tribes) is subtruncate at apex, whereas the same sternite in the female is somewhat narrowly rounded, though at times it is practically impossible for even an experienced student of the group to be certain of the sex unless he dissects the specimen. This condition, however, does not hold good throughout the tribe, since males of the Neotropical *Amblyodus* Westwood show the typical emargination of the last sternite.

KEY TO UNITED STATES GENERA AND SPECIES

1. Completely lacking any tubercles or horns on either head or thorax; clypeal base consisting of a wide carina which is obsolescent laterally; front not at all concave, but coarsely punctate; side of thorax exceptionally hairy (hairs really extend from beneath thoracic margin); elytra short and very coarsely cribrate; apex of hind tibia slightly irregular but not really toothed; all tarsal segments short and subrectangular in shape; elytra "soldered" at sutures and wings reduced to mere vestiges. . . . . *Archophileurus cribrosus* (LeConte)
   With tubercles or horns on either head or thorax or both, without transverse clypeal carina; front always strongly concave; elytra longer, depressed; hind tibial apex distinctly spinose, at least at sides; tarsal segments longer, basal segment of mid and hind legs with strong apical spine; elytra not soldered at suture and wings of normal length. (*Phileurus*). 3
2. Size large (29–34 mm); clypeal horn very large, as long as exposed dorsal portion of head, each horn situated right *at* and *on* lateral margin of head; small canthus in front of eye (dorsal view) very obsolescent, not at all conspicuous. . *Phileurus truncatus* (Beauvois)
   Size much smaller (16–23 mm); clypeal horn small or represented by a tubercle, always much shorter than head length; clypeal horn situated *inside* each lateral margin, and not *at* it; eye canthus moderate to strong. 3
3. Front tibia distinctly 4-dentate, the subapical and apical external teeth very narrowly separated by a distinctly U-shaped incision; the sides of the "incision" parallel. *Phileurus castaneus* Haldeman
   Front tibia tridentate, at most with the merest suggestion of a fourth tooth (near base if present) apical and subapical external tooth separated by a *wide* non-parallel-sided emargination. . . . . *Phileurus illatus* LeConte

Genus **Archophileurus** Kolbe

Archophileurus Kolbe, 1910, p. 334; Casey, 1915, p. 271; Arrow, 1937, p. 38; Cazier, 1399, p. 170.

Arrow in his 1937 catalogue lists a number of American species in this genus, some of these however actually being synonyms, but the group is not well enough known to definitely list them as such at the present time. Our single United States species also occurs in northern Mexico:

Archophileurus cribrosus (LeConte)

Fig. 1, *b*

Phileurus cribrosus LeConte, 1854, p. 80; Bates, 1887, p. 338.
Archophileurus cribrosus (LeConte) Casey, 1915, p. 264; Arrow, 1937, p. 87; Cazier, 1939, p. 170.

Judged from collected specimens apparently the center of distribution of this species is in

northern Mexico (Durango, Coahuila, and Tamaulipas), with further distribution in the southwestern United States (Texas, Arizona, and New Mexico). Nothing is known regarding its habits. The slender vestigial wings are interesting, and owing to this flightless condition we might expect to find local races in such a wide-ranging form.

Genus **Phileurus** Latreille

Phileurus Latrielle, 1807, p. 103; Burmeister, 1947, p. 148; Lacordaire, 1856, p. 456; Kolbe, 1910, p. 336; Casey, 1915, p. 264; Arrow, 1937, p. 89; Cazier, 1939, p. 170.

In his 1937 catalogue Arrow lists 27 species, at least 10 of which are known to me to be synonyms. The species range generally throughout the Americas and the West Indies. The larvae live in decaying wood. Because of the flattened dorsal surface and the black color, these *Phileurus* are often mistaken for passalid beetles, which they do indeed superficially resemble.

Phileurus truncatus (Beauvois)
Fig. 1, *a*

Scarabaeus truncatus Palisot de Beauvois, 1807, p. 41.
Phileurus truncatus (Beauvois) Casey, 1915, p. 265; Bates, 1889, p. 340; Arrow, 1937, p. 90; Cazier, 1939, p. 170.
Phileurus recurvatus Casey, 1915, p. 266.

Recorded by Bates and Casey from Mexico and ranging also rather commonly throughout our southeastern United States. Has been recorded as mistaking chimneys for hollow trees and thus falling into fireplaces. The large size and strong cephalic horns readily place the species.

Phileurus illatus LeConte
Fig. 1, *c*

Phileurus illatus LeConte, 1854, p. 80; Casey, 1915, p. 267; Ritcher, 1944, p. 47 (larvae).
Phileurus vitulus LeConte, 1866, p. 80; Cazier, 1939, p. 170.
Phileurus phoenicis Casey, 1915, p. 267; Cazier, 1939, p. 170.
Phileurus puncticollis Casey, 1915, p. 268; Cazier, 1939, p. 170.
Goniophileurus femoratus (Burmeister) Kolbe, 1910, p. 149, p. 344 (pars); Arrow, 1937, p. 86, 90; Blackwelder, 1944, pp. 257–258; Cazier, 1939, p. 170.

There has been a great deal of controversy about and incorrect citations for this species since Kolbe erected the genus *Goniophileurus* for *femoratus* Burmeister and placed *illatus* LeConte and *vitulus* LeConte as synonyms of it. Burmeister's types of *femoratus* were from French Guiana and this name (the species is unknown to me) should apply to that locality, and *vitulus* and *illatus* should be removed from the synonymy of that species. Kolbe's main character for the genus *Goniophileurus* was the 2- or 3-toothed mandible, whereas my dissections show without doubt that the mandibles of our U. S. species are quite *simple.* Thus in the catalogues of Arrow (1937) and of Blackwelder (1944) following Arrow, *vitulus* and *illatus* are listed both as synonyms of *Goniophileurus femoratus* (Burmeister) and also as valid species of *Phileurus;* actually, they have nothing to do with *femoratus*, and *vitulus* is a synonym of our common *illatus*.

Ritcher has studied larvae taken in the trunks of trees (*Dasylirion*) in Arizona. The species occurs fairly commonly in Arizona, very rarely in southern California and in northern Mexico and Lower California (Triunfo, July 7, Ross and Michelbacher). I have also seen a specimen some time ago, apparently of this species, taken from the La Brea tar pits in southern California, probably representing a specimen of the (?) Pleistocene period.

Phileurus castaneus Haldeman
Fig. 1, *d*

Phileurus castaneus Haldeman, 1843, p. 304; Casey, 1915, p. 270; Arrow, 1937, p. 89; Cazier, 1939, p. 170; Ritcher, 1944, p. 42 (larvae).
Phileurus valgus Olivier (nec Linnaeus), 1789, p. 43; Arrow, 1937, p. 89.
Phileurus texensis Casey, 1915, p. 268; Cazier, 1939, p. 170.
Phileurus sulcifer Casey, 1915, p. 269; Cazier 1939, p. 170.
Phileurus floridanus Casey, 1915, p. 270; Cazier, 1939, p. 170.
Phileurus carolinae Casey, 1915, p. 269; Cazier, 1939, p. 170.

Arrow in his 1937 catalogue lists four varieties of this species from the West Indies and South America. It is a fairly common species in the United States, ranging from Virginia through the Southern States and Florida and Texas into Mexico, and supposedly also Guatemala. Ritcher has reared the larva from a specimen collected in a cavity of a dead Basswood tree.

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ORNITHOLOGY.—*Note on the races of the black-throated sunbird,* Aethopyga saturata (*Hodgson*).[1] J. DELACOUR, American Museum of Natural History. (Communicated by HERBERT FRIEDMANN.)

While I was in Europe in the summer of 1947, I made a complete examination of the specimens of *Aethopyga saturata* preserved in the Museums of Paris and London at the instance of H. G. Deignan, who has recently revised the races of the species, using the material available in the United States. I found that the races stand as he has indicated in his recent paper (This JOURNAL **38**: 21–23. 1948) with one addition. Also new indications are supplied by the specimens in the Paris and London collections, many of which have been collected by me in Indochina. The metallic blue, or dull black, coloration of the middle of the throat of the males is an important characteristic, but it is not quite stable, and specimens varying in that way may be found apparently in several populations. I have listed the following ratios of metallic and dull throats in two subspecies from the specimens deposited in Paris and London.

Subspecies and locality	*Metallic throat*	*Dull throat*
sanguinipectus:		
Karenni	3 (including type)	1
Tenasserim	9	0
petersi:		
Southern Shan States	0	14
Haut Laos	2	9
Tongking	2	6

Even in specimens with a completely metallic blue throat the center is always somewhat duller than the sides, so that in some cases it is a question of degree and there is a gradation between the two ex-

[1] Received January 30, 1948.

tremes. Also there is a good deal of variation in the intensity and extent of the yellow of the underparts among specimens from Tongking and Haut Laos. Two males from Dakto, Central Annam, are similar to specimens from the Boloven Plateau and should be referred to *ochra*.

Mr. Deignan was unable to examine material from Bokor, southwestern Cambodia. This population is isolated on the Chaînes des Eléphants et des Cardamomes and has special characteristics. I propose to call it:

Aethopyga saturata cambodiana, n. subsp.

Type.—Brit. Mus. Nat. Hist. no. 1578, adult male, collected at Bokor, Cambodia, on December 12, 1927, by J. Delacour (original number 793).

Diagnosis.—Nearest to *ochra* Deignan (Bas Laos and Central Annam), differing in having the middle of throat usually metallic blue, not dull black, the mantle of a darker maroon red color and the abdomen grayer. Resembles *sanguinipectus* Walden (South Burma), but darker red on the mantle. In its dark mantle and metallic throat it approaches *johnsi* Robinson and Kloss (South Annam), which, however, is very distinct from all other races in the almost plain red color of the breast. Iris dark brown; bill black; legs blackish brown. Female similar to *petersi*, very yellow underneath.

Range.—The mountains of southwestern Cambodia and probably the border of Siam.

Specimens examined.—8 males, 3 females.

Remarks.—One of the males (Paris) has the center of throat dull black.

ORNITHOLOGY.—*Some races of the babbling thrush,* Malacocincla abbotti *Blyth*.[1] H. G. DEIGNAN, U. S. National Museum.

Despite the fact that this common babbler is generally admitted to show normal subspecific variation in the Malaysian Subregion, ornithological writers have consistently held that the nominate race ranges, without the least geographical change, from the eastern Himalayan foothills to Malaya and Indochine. Inasmuch as the rich material before me shows undeniable subspeciation, it must be supposed that lack of specimens from Arakan, the type locality of the species, has inhibited its proper study in the past.

It may be said at once that I have not myself seen a single topotype of *Malacocincla abbotti* and that all remarks to follow are based upon the premise that specimens from southwestern Siam and northern Tenasserim represent the Arakanese form—an assumption supported by careful comparison of these birds with the original description of Blyth (Journ. Asiat. Soc. Bengal **14**, pt. 2: 601. Aug. 1845).

In my diagnoses of new subspecies, only fresh-plumaged adult examples have been employed, and "foxing" has been taken into account by comparison of birds of approximately the same date of collection. After these precautions, I still find it necessary to name three races from Siam alone. Their descriptions follow.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 16, 1948.

1. **Malacocincla abbotti rufescentior,** n. subsp.

Type.—U. S. N. M. no. 330572, adult female, collected at Ban Tha Lo, southwest of Surat Thani or Ban Don (*ca.* lat. 9°05′ N., long. 99°15′ E.), peninsular Siam, on September 20, 1931, by Hugh M. Smith (original number 4982).

Diagnosis.—Separable in series from *M. a. abbotti* (as exemplified by birds from southwestern Siam and northern Tenasserim) by having the upperparts slightly more rufescent, and especially by having the underparts (except the white throat and abdomen) more strongly washed with a much brighter ferruginous.

Range.—Peninsular Siam (except Pattani Province) and southern Tenasserim.

Remarks.—*M. a. rufescentior* is distinguishable from *olivacea* of Pattani Province and Malaya by the same characters as separate it from *abbotti*. The material before me does not show any very obvious difference between *abbotti* and *olivacea*, although the latter seems to have the upperparts the least bit darker in tone; larger series would probably show this better.

Twenty-four winter-taken adults of *rufescentior* have been examined.

2. Malacocincla abbotti obscurior, n. subsp.

Type.—U. S. N. M. no. 333912, adult male, collected at Khao Sa Bap (lat. 12°35′ N., long. 102°15′ E.), Chanthaburi Province, southeastern Siam, on October 25, 1933, by Hugh M. Smith (original number 6545).

Diagnosis.—Separable in series from *M. a. rufescentior* by having the coloration of the crown, especially anteriorly, darker and more olivaceous; by having the remaining upperparts equally rufescent, but decidedly deeper in tone; and by having the rufescent of the underparts (excepting the white throat and abdomen) slightly brighter and deeper.

Range.—Southeastern Siam.

Remarks.—Twenty-five winter-taken adults of *obscurior* have been examined.

3. Malacocincla abbotti williamsoni, n. subsp.

Type.—U. S. N. M. no. 324357, adult male, collected at Sathani Pak Chong, eastern Siam at lat. 14°40′ N., long. 101°25′ E., on November 16, 1929, by Hugh M. Smith (original number 3457).

Diagnosis.—Like *M, a. obscurior* in the dark coloration of the crown but easily distinguishable from it in series by having the remaining upperparts olivaceous brown, but slightly suffused with rufescent, and by having the underparts (except the white throat and abdomen) more lightly washed with a paler ferruginous.

From *M. a. abbotti*, which it resembles beneath, *williamsoni* is separable by the deeper tone of the more olivaceous-brown upperparts and the darker coloration of the crown.

Range.—Eastern Siam and Laos (Vientiane).

Remarks.—This race is named in honor of Sir Walter J. F. Williamson, C.M.G., the well-known student of Siamese ornithology.

Eleven winter-taken adults of *williamsoni* have been examined.

ZOOLOGY.—*Two new millipeds of Jamaica.*[1] H. F. Loomis, Coconut Grove, Fla.

Late in January and early in February, 1937, Dr. E. A. Chapin, curator of insects, United States National Museum, collected insects and members of lower groups in Jamaica. The millipeds included in this collection were sent to me for identification, there being eight species of which two appear to be undescribed, one representing a new generic type. These two new millipeds are here described and the previously known species in the collection listed. All specimens have been deposited in the National Museum.

Glomeridesmus angulosus, n. sp.

One male (type) and six other specimens in bottle labeled only "Sifting fern gully, Feb. 2," but probably collected at Moneague, where other collecting was done the same day.

Diagnosis.—This is the smallest West Indian species of the genus and has the posterior corners of more of the caudal segments produced into acute angles than any other species. The last male legs also are distinctive.

Description.—Length of largest specimen, a female, with 21 segments, 4 mm, width 1 mm; largest male, with 20 segments, 3 mm long. The generally dark color of living animals probably is almost entirely derived from the internal organs showing through the quite transparent and colorless body wall noticeable in preserved specimens.

The pit behind each antenna is circular and not opened on any side, nor is the antennal socket opened behind or below although there is a depression below it as in the Haitian *G. jenkinsi* Loomis.

From segment 12 or 13 to segment 19 inclusive the posterior corners are increasingly produced into acute angles as shown in Fig. 1.

Basal joint of the legs with posterior margin minutely serrate. Pleurae with about three transverse ridges in front, the back margin smooth but with 6 to 8 minute, short, projecting setae; inner posterior corner acute. Penultimate legs of male with basal joints directed outward, the three terminal ones bent caudad. Last male legs with only the two terminal joints projecting beyond the penultimate legs, modified as shown in Fig. 2.

Siphonophora robusta Chamberlin

A female, apparently of this species from Moneague, station 370, February 2.

[1] Received January 16, 1948.

Rhinocricus sabulosus Pocock

A female from Moneague, station 370, February 2, and several specimens from "under dung" at Mocho, February 16.

Rhinocricus solitarius Pocock

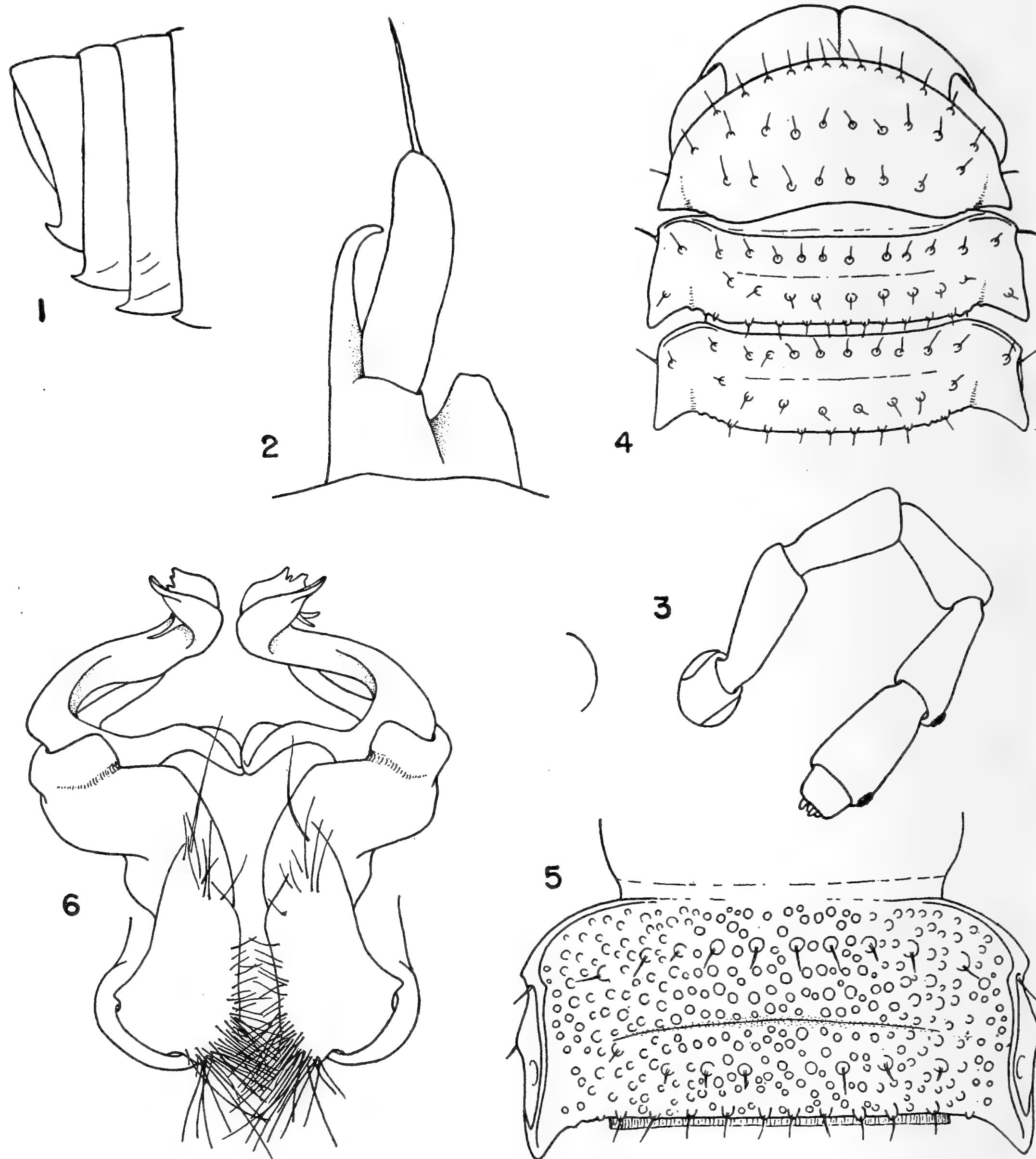
A male collected with *R. sabulosus* above.

Rhinocricus sp.

A young specimen from near White Horses, station 386, February 6.

Spirostrophus naresi (Pocock)

Numerous specimens from Bath St. Thomas, February 6 and 8.



FIGS. 1–2.—*Glomeridesmus angulosus*, n. sp.: 1, Segments 16 to 20, lateral view; 2, two apical joints of last male leg on left side, ventral view over penultimate leg.
FIGS. 3–6.—*Xaymacia granulata*, n. sp.: 3, Antenna and part of opposite socket; 4, head and first penultimate three segments, the nonsetiferous tubercles not shown; 5, segment 9 of male showing typical dorsal sculpture; 6, gonopods, ventral view.

Xaymacia, n. gen.

Genotype.—*Xaymacia granulata*, n. sp.

Diagnosis.—From the shape of the gonopods it does not appear that this genus has any close relatives in the known chelodesmid fauna of the West Indies or the mainland surrounding the Caribbean area. The ornamentation of the dorsum is not duplicated in other members of the family in the region.

Description.—Body of the size and proportions of the common *Orthomorpha coarctata* (Saussure) with which species specimens were collected in several localities. Males more slender and with the dorsum flatter than females. Dorsum thickly granulate in addition to three transverse series of slightly larger setose tubercles on segments 1 to 19, inclusive.

Head large, as wide as segment 1; a strong sulcus on the vertex; antennae separated by little more than the diameter of one of the sockets, geniculate at joint 4; joints 5 and 6 with a group of sensory hairs on the outer side near apex.

Produced posterior corners of lateral keels, from segment 2 to 18 inclusive, subequal in size. Pore formula normal, the pores opening outward from the margin of the carinae. Sterna sparsely hispid.

Gonopods with the apical half of the posterior division slender, pointed, and curving behind and partly obscured by the anterior division which is biramose and with its apical half in a sigmoid curve.

The generic name is in reference to the old name "Xaymaca" from which the modern name of Jamaica was derived.

Xaymacia granulata, n. sp.

From January 28 to February 8, 1937, numerous specimens were collected at the following localities: Caymanas, along Rio Cobre, (male type); Annotto Bay; Half Way Tree; Hope Gardens; Bath St. Thomas.

Description.—Length 16 to 18 mm; body parallel-sided from segment 1 to 16; males definitely more slender than females and the dorsum flatter, nearly horizontal; general size and color very similar to *Orthomorpha coarctata* (Saussure)

Living color dark brown except for the corners of segment 1 and the lateral carinae of succeeding segments which are light yellow, the color being restricted to the outer margin of the carina at the front of each segment but broadening to include the entire posterior corner; last segment wholly brown; sterna, legs, preanal scale, and the anal valves colorless.

Head almost as wide as remainder of body; strongly and evenly inflated, subglobose, with a very definite sulcus extending across the vertex to between the antennae; the vertex shining, glabrous behind, sparsely and finely hispid in front, the remainder of the head much more densely hispid with erect hairs varying in length from very short to others several times as long. Antennae close together near the front of the head, separated by little more than the diameter of one socket, shaped as shown in Fig. 3; joints 5 and 6 each with a small area of sensory hairs near apex on the outer side.

First segment semicircular, strongly convex, with the posterior corners depressed, thin, horizontal, rather acute but not produced backward; surface densely scattered with small vesiclelike granules as high as broad, and three transverse rows of slightly larger setiferous granules, 12 of which are along the anterior margin, 10 in the median row and 8 to 10 somewhat in advance of the posterior margin; a single seta projects outward from the margin just in advance of the posterior corner.

Ensuing segments with granules and transverse rows of setiferous tubercles similar to those of segment 1; a pronounced transverse sulcus crosses the middle of each segment and the lateral carinae have one or two setae projecting outward from the outer margin (Fig. 4). Second segment with the outer margin of the keels slightly longer than on ensuing ones, the posterior corners produced backward in the same degree which remains uniform to segment 18, corners of segment 19 reduced to half size; from segment 5 backward the outer margin of the keels thickened and containing an elongate impressed area opening outward, this being much broader in the poriferous keels (Fig. 5). Pore formula normal.

Last segment short, conical, abruptly narrower at apex, the dorsal surface lacking granules except those bearing the setae, there being an anterior row of six of these and a posterior, subapical, row of four, the outermost actually being on the lateral surface.

Preanal scale large, triangular, the posterior margin of segment 19 just in front of it with 6 to

10 marginal setae. Anal valves moderately inflated, the margins thinly elevated.

Sterna sparsely hispid with long erect hairs. Sterna of fourth male legs with two rather large conical tubercles, other sterna and legs normal. Gonopods as shown in Fig. 6.

Orthomorpha coarctata (Saussure)

Numerous specimens collected at Annotto Bay, January 30; Half Way Tree, January 28 and 31; Caymanas, on sandy beach along Rio Cobre, February 3.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

416TH MEETING OF BOARD OF MANAGERS

The 416th meeting of the Board of Managers, held in the Cosmos Club, March 15, 1948, was called to order at 8 P.M. by the President, DR. F. D. ROSSINI. Others present were: H. S. RAPPLEYE, W. L. SCHMITT, W. W. DIEHL, F. M. DEFANDORF, C. F. W. MUESEBECK, R. BAMFORD, W. A. DAYTON, F. B. SILSBEE, M. A. MASON, A. O. FOSTER, L. A. ROGERS, C. L. GARNER, C. L. GAZIN, and, by invitation, H. E. MCCOMB, R. J. SEEGER, and L. V. JUDSON.

The President announced the appointment of a Committee on Science Legislation: J. E. GRAF, Chairman, A. T. MCPHERSON, W. W. RUBEY.

It was reported that the Executive Committee had agreed to accept an invitation to join with the Library of Congress, the American Council of Learned Societies, and the Foundation for Integrated Education in cosponsoring a memorial meeting in honor of the late Alfred North Whitehead at the Library of Congress on Sunday, March 21, 1948.

The Executive Committee recommended to the Board that an allotment of $20 be made to the Membership Committee to cover expenses of office, including the preparation of mimeographed summaries of the new-member qualifications for presentation to the Board.

The Chairman of the Committee on Meetings, DR. R. J. SEEGER, announced that the March meeting would be given over to the Academy Award winners for 1947.

The secretary read the following report submitted by a committee appointed to consider the creation of an office of President-Elect, increase in the permitted number of members, and the addition of two standing committees:

The Committee met on 25 February 1948 in the office of Dr. Gazin at the National Museum to consider the questions referred to it by the Board of Managers, namely, the questions of creating the office of "President-Elect" of the Washington Academy of Sciences, of increasing the permitted number of members, and of adding the Committee on Awards for Scientific Achievement and the Committee on Grants-in-Aid for Research to the standing committees of the Board of Managers.

The Committee recommends the creation of the office of President-Elect to promote continuity of policies and objectives of the Academy by acquainting the income president with the current business and the administrative routine of the Academy.

The Committee regards with favor the proposal to raise the permitted number of members of the Academy since this would make possible an expansion of the Academy more nearly in proportion to the growth of Washington as a center of science, and would at the same time provide additional income for the Academy. However, the Committee feels that the increase in number should be a modest one. A large increase would create so many vacancies that there might be a danger of lowering the standards of admission of the Academy. The Committee suggests that the permitted number of active members be raised from 650 to 700 and the number of resident active members from 500 to 550. The Committee feels that such action would provide ample room for suitable candidates for several years to come, especially since there are at present about 20 vacancies in the Academy.

The Committee recommends increasing the number of standing committees of the Board of Managers from four to six to include the Committee on Awards for Scientific Achievement and the Committee on Grants-in-Aid for Research. Both of these committees have been standing committees in effect for the past several years.

[There followed a list of suggested changes in the Bylaws and Standing Rules to carry out these recommendations.]

The Board accepted the report and instructed the Secretary to submit to a vote of the membership the recommended changes in

the Bylaws, with the emendation that the increase in the number of members permitted in the Academy be changed from 50 to 100. Changes in the Standing Rules were accepted with one amendment. These changes are required to be presented at the next meeting of the Board for final approval.

Upon further discussion of the composition and duties of the various standing committees, it was voted that the present Special Committee that recommended the changes in the Bylaws look into the matter of the tenure of membership in the standing committees to consider the suggestion that some arrangement be made to permit a rotation or carry-over of a certain number of each committee to the succeeding year, in order to facilitate functioning of the committee and continuity in plans.

The Secretary reported the request by Dr. O. E. Meinzer that H. Freeborn Johnston be reinstated as a member of the Academy. Mr. Johnston resigned in 1939 as a result of ill health. The Board voted to reinstate him to membership.

The Secretary reported the death of Dr. Nelson Horatio Darton, formerly with the Geological Survey, an original member of the Academy, on February 28, 1948; and of Dr. William Ralph Maxon, formerly curator of the U. S. National Herbarium, Smithsonian Institution, on February 25, 1948.

The Board approved the request of Dr. Oscar Riddle to be placed on the retired list, effective December 31, 1946.

The Senior Editor, Dr. J. I. Hoffman, reported that he had read the monograph referred to the Board of Editors for comment and had found it to be in good order and worthy of publication. The monograph, *The Parasitic Birds of Africa*, by Dr. Herbert Friedmann, was then referred to the new Committee on Monographs for its recommendations. Dr. Hoffman then brought up the question of the proposed index to the first 40 volumes of the Journal, and after some discussion the President was authorized to appoint a committee to consider the index and make recommendations on its publication.

The Board accepted the nomination of Dr. T. Dale Stewart as a Vice-President of the Academy representing the Anthropological Society, replacing Dr. W. N. Fenton who withdrew from this office because of his election to the Board of Managers.

Item 9 of the recommendations of the Committee to consider "various matters pertaining to the Journal and its improvement," carried over from the unfinished business of the previous meeting of the Board, was again discussed. The President was authorized to appoint the committee recommended, i.e., to study the functions of the Academy and to formulate a program that will integrate these functions, including the Journal. The Board requested that this committee make its report by January 1949.

The meeting was adjourned at 10:15 p.m.

C. L. Gazin, *Secretary*

NEW MEMBERS OF THE ACADEMY

There follows a list of persons elected to membership in the Academy, by vote of its Board of Managers, since January 13, 1947, who have since qualified as members in accordance with the bylaws. (See also previous list in January 15, 1948, issue of the Journal.) The bases for election are stated with the names of the new members.

RESIDENT

Elected January 13, 1947

Joseph P. E. Morrison, zoologist, U. S. National Museum, in recognition of his scientific attainments in the field of malacology, especially for his studies on the taxonomy, anatomy, and biology of the fresh-water mollusks.

Elected October 6, 1947

Earle K. Plyler, physicist, National Bureau of Standards, in recognition of his work on the structure of molecules from infrared spectra, chemical analysis by infrared absorption measurements, and properties of matter as exhibited by characteristic absorption spectra.

Elected December 15, 1947

Robert C. Cook, biologist, managing editor of the Journal of Heredity, in recognition of his services to biology, in particular his long-time distinguished editorship of the Journal of Heredity.

Ira A. Gould, Jr., chemist, University of Maryland, in recognition of his studies on the chemistry of milk, especially of the chemical

changes brought about by the application of heat.

TIREY F. FORD, chemist, Bureau of Dairy Industry, in recognition of his contributions to the ultracentrifugal measurement of micellar sizes and in particular his researches on the particle size of the proteins of milk.

HAROLD H. SHEPARD, entomologist, U. S. Department of Agriculture, in recognition of his contributions to entomology, particularly the action of insecticides, the biology of stored products, insects, and the bibliography of the Hesperiidae.

PAUL R. MILLER, plant pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of his contributions to the science of plant pathology and in particular his researches on apple rusts and on plant-disease survey methods, including spore load studies, development of new techniques, epidemiological studies, etc.

W. GARDNER LYNN, biologist, Catholic University of America, in recognition of his studies in embryology and herpetology.

HUGH T. O'NEILL, botanist, Catholic University of America, in recognition of his contribution to systematic botany, especially the Cyperaceae and Arctic plants.

LEE LING, plant pathologist, Food and Agricultural Division, United Nations Organization, in recognition of his contributions to the mycology and plant pathology of China.

GEORGE D. ROCK, physicist, Catholic University of America, in recognition of his contributions to ultrasonics.

FRANCIS E. FOX, physicist, Catholic University of America, in recognition of his work in ultrasonics, particularly on the absorption of ultrasonic waves in liquids.

JOSEPH S. CALDWELL, physiologist, U. S. Department of Agriculture, in recognition of his studies in the physiology of fruit and vegetable processing.

FRANK L. CAMPBELL, entomologist, editor of the Scientific Monthly, in recognition of his researches in entomology, in particular the physiology of insects in relation to toxicology.

RICHARD S. DILL, engineer, Heating and Air Conditioning Section, National Bureau of Standards, in recognition of his outstanding research in the fields of heating, insulation, and air-conditioning of structures.

JOHN K. TAYLOR, chemist, National Bureau of Standards, in recognition of his work on electrode potentials, refractive index, and polarography.

J. BROOKES KNIGHT, paleontologist, U. S. National Museum, in recognition of his contributions to the knowledge of Paleozoic Gastropoda.

DORIS M. COCHRAN, zoologist, U. S. National Museum, in recognition of her scientific work in taxonomic herpetology, especially for the *Herpetology of Hispaniola*, U. S. National Museum Bulletin 177, 1941.

Elected January 12, 1948

JOHN C. EWERS, ethnologist, U. S. National Museum, in recognition of his research on the material culture and arts and crafts of the Plains Indians in historic times.

WALTER S. DIEHL, engineer, Bureau of Aeronautics, Department of the Navy, in recognition of his contributions to aerodynamics and to aeronautics.

ASHLEY B. GURNEY, entomologist, Bureau of Entomology and Plant Quarantine, in recognition of his contributions to the taxonomy of the Orthoptera, Corrodentia, Neuroptera, and Zoraptera.

HARRY A. BORTHWICK, botanist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of his work in plant physiology and in particular his researches on photoperiodism in relation to plant morphology.

MARION W. PARKER, botanist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of his work in plant physiology and especially on the relation of light and temperature to plant growth.

PHILIP BRIERLEY, plant pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of his contributions to plant pathology, particularly in clearing up the nature and complexity of the virus diseases of *Lilium longiflorum*.

WILBUR D. MCCLELLAN, plant pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, in recognition of his work on use of fungicides and interaction of nutritives and fungicides in the pathogenicity of certain organisms.

PAUL C. MARTH, botanist, Bureau of Plant Industry, Soils, and Agricultural Engineering,

in recognition of his work in plant physiology, in particular his pioneering research on the effects of growth regulators on plants and fruits.

Floyd F. Smith, entomologist, Bureau of Entomology and Plant Quarantine, in recognition of his investigations of insects as vectors of viruses and the application of aerosols to insect enemies of ornamental plants.

NONRESIDENT

Elected January 13, 1947

Agesilau A. Bitancourt, biologist, Instituto Biológico São Paulo, Brazil, in recognition of his contributions to tropical researches in plant pathology, particularly in citrus diseases.

Elected December 15, 1947

Julian H. Miller, plant pathologist, University of Georgia, Athens, Ga., in recognition of his researches in mycology, in particular his contributions on the comparative morphology and taxonomy of the Sphaeriales.

Ernest H. Volwiler, chemist, Abbott Laboratories, North Chicago, Ill., in recognition of his contributions to organic chemistry, particularly the synthesis of organic medicinals.

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held on January 7, 1948, elected the following officers: President, William N. Fenton; Vice-President, W. Montague Cobb: Secretary, Marshall T. Newman: Treasurer, John C. Ewers: Councilors to the Board of Managers, E. Wyllys Andrews IV, Stella L. Deignan, George M. Foster, William H. Gilbert, Jr., Gordon R. Willey; Representative to the Washington Academy of Sciences, T. D. Stewart.

A report of the membership and activities of the Society since the last annual meeting follows:

Life members, 1; Active members, 62; Associate members, 20; Total, 83. This represents a decrease of six since last year.

The members elected during the year were: Active members: Dr. E. W. Andrews, Comdr. Sydney Connor, J. R. Caldwell, Dr. N. Datta-Majumder, Dr. Philip Drucker, Miss E. C. Davis, Dr. C. E. Hutchinson, Dr. D. W. Lockard, Dr. W. O. Negherbon, Dr. Philleo Nash, Dr. M. H. Watkins, Associate member: Dr. George M. Foster.

The Society records its deep sense of loss at the death of Dr. Beatrice Bickel, member since 1933.

Except for the joint meeting with the Washington Academy of Sciences at the Cosmos Club on January 16, 1947, all regular meetings were held at the U. S. National Museum. The Program Committee for the year comprised Dr. Marshall T. Newman, *chairman*, and Dr. Margaret Lantis.

Titles of papers presented before the regular meetings of the Society were:

January 16, 1947, 739th meeting, Waldo R. Wedel, *Archeology and the Missouri River development program* (slides; refreshments served by Washington Academy of Sciences).

February 18, 1947, 740th meeting, R. Ruggles Gates, *Human ancestry from a geneticist's viewpoint* (slides).

March 18, 1947, 741st meeting, Preston Holder, *The Motilon Indians, an untouched tropical forest group in northwestern South America.* (Published in this Journal **37**: 417–427, 1947).

April 15, 1947, 742d meeting, W. Montague Cobb, *The American Negro in the light of modern physical anthropology* (slides).

May 23, 1947, 743d meeting (joint meeting with the Medico-Chirurgical Society of the District of Columbia), Wilton M. Krogman, *Anthropology and race relations.*

October 21, 1947, 744th meeting, Father Ernst Worms, *The natives of northwestern Australia—a contemporary picture of their language and culture* (sound color film).

November 5, 1947, 745th meeting, George M. Foster, *The People of Tzintzuntzan—a contemporary study of social and economic adjustment in Mexico* (color films).

December 3, 1947, 746th meeting, Eugene C. Worman, Jr., *The neolithic period in India—new evidence on early cultural movements in Asia.*

The Society voted to freeze the Perpetual Building fund at $2,000 and to subsequently add the interest to dues and other income for running expenses. In this way the scope of activities can be enlarged. It was decided also to govern annual expenditures by a budget estimate made at the start of each year.

The report of the Treasurer follows:

Income:		
A.S.W. dues collected	$ 112.00	
Back dues (A.A.A.) collected to reimburse A.S.W. for carrying delinquents	5.00	
Interest, Perpetual Building Association	57.38	
Dividends, Washington Sanitary Improvement Co.	33.60	
Dividends, Washington Sanitary Housing Co.	12.00	
Interest, U. S. Savings Bond	12.50	
Sale of Old Series *Anthropologists*	7.60	
		$ 240.08
Expenditures:		
A.A.A. dues paid for Secretary and one life member	10.00	
Expenses, speakers	60.00	
Dues, Inter-American Society of Anthropology and Geography	3.00	
Printing and mailing notices	77.03	
Incidental meeting expenses	24.00	
Miscellaneous expenses, Secretary and Treasurer	9.64	
		183.67
Balance		$ 56.41
Assets:		
Funds invested in Perpetual Building Association (with interest to Dec. 31, 1947)	$1,956.50	
21 Shares Washington Sanitary Improvement Co. (par value $10 per share)	210.00	
2 Shares Washington Sanitary Housing Co. (par value $100 per share)	200.00	
U. S. Savings Bond, Series G.	500.00	
Cash in bank	261.65	
Total as of December 31, 1947		$3,128.15
Total as of December 31, 1946		3,071.74
Increase		$ 56.41
Less bills outstanding:		
To A.A.A. (Subscriptions to *American Anthropologist*):		
For 1 member, 3 years, 1948–50	$ 15.00	
For 1 member, 1 year, 1948	5.00	
		20.00
Net increase		$ 36.41

MARSHALL T. NEWMAN, *Secretary.*

Officers of the Washington Academy of Sciences

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) Short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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PHYSICS.—*Mass spectra of hydrocarbons.*[1] Fred L. Mohler, National Bureau of Standards.

Mass spectra were first observed by J. J. Thompson by passing canal rays through transverse electric and magnetic fields. His discovery in 1913 (*1*) that there appeared to be two isotopes of neon led Aston (*2*) to much more elaborate experiments. For many years interest centered in discovery of new isotopes and precision atomic-weight measurements. Studies of molecular mass spectra were largely an American development. (*3*) The purpose was to study the mechanism of ionization of polyatomic molecules. Later Hipple (*4*) at Westinghouse and Washburn (*5*) of the Consolidated Engineering Corporation developed this type of mass spectrometer into an instrument suitable for chemical analysis of gas mixtures. The requirements for such an instrument are accurate automatic electrical recording and reliable reproducibility.

An important feature introduced by Bleakney was the ionization chamber in which the ions were produced. A beam of univelocity electrons traverses the ionization chamber and a magnetic field parallel to the beam keeps this beam centered while a small transverse electric field draws the ions produced out of the ionization chamber. The ions are then accelerated by a large electric field and bent by a magnetic field to give a mass spectrum.

The gas to be ionized enters the ionization chamber in a jet at very low pressure (about 10^{-4} mm), and fast pumps maintain a pressure of about 10^{-6} mm outside the ionization chamber. This insures ideally simple conditions. There is no appreciable accumulation of ionization products in the ionization chamber and there are no collisions between ions and gas molecules. As the applied voltage of the electron beam is increased, molecule ions first appear at about 10 to 12 volts. Then with increasing voltage, ions of various dissociation products are formed. Twenty-five or 30 volts are sufficient to produce almost every possible dissociation product of a hydrocarbon and, in the range 50 to 100 volts, the relative intensities of the molecule ion and the various dissociation products remain nearly independent of voltage. The resulting mass spectrum is a property of the molecule modified only slightly by instrumental factors.

In the Consolidated mass spectrometer the ions from the ionization chamber are accelerated by a variable electric field and bent through an arc of 180° by the field of a large magnet to reach a collecting electrode. After passing through the electric field V all the singly charged ions will have the same kinetic energy $1/2\ mv^2 = eV$ and light ions will have a high velocity and heavy ions a small velocity. The magnetic field exerts a force proportional to the velocity at right angles to the field and to the velocity. Ions of mass m and charge e will move on the arc of a circle of radius R defined by the relation $m/e = CH^2\ R^2/V$ where C is a constant, H is the magnetic field, and V the ion accelerating voltage. If V is gradually changed from high to low values, ions of different masses will successively reach the ion collector. The current reaching the collector is amplified and recorded by galvanometers on a moving sheet while $1/V$ changes at a uniform rate. Thus, the resulting record shows a series of peaks at the values of $1/V$ or m/e corresponding to the molecular weights of the compound and its dissociation products.

[1] Address of the retiring President of the Philosophical Society of Washington, January 17, 1948. Received March 17, 1948.

Fig. 1 is part of the mass spectrum record obtained with a Consolidated mass spectrometer of n butane, $CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_3$. Four galvanometers with four ranges of sensitivity record the ion current. The upper trace records the galvanometer of highest sensitivity. Deflections of the other galvanometer traces are to be multiplied by 3, 10, and 30 to give deflections in terms of the upper trace. The parent peak, the undissociated molecule ion, is at mass 58 and a peak at 59 comes from molecules containing one C^{13} isotope. Then there are molecules which have lost from 1 to 10 hydrogen atoms. It is a remarkable fact that in a single ionization process all ten hydrogen atoms can be removed to give C_4^+. The most probable ionization process is losing CH_3 to give mass 43. Losing an additional CH_2 to give 29 is also probable.

One finds indeed every possible dissociation process consistent with the structural formula. Peaks at $25\frac{1}{2}$ and $26\frac{1}{2}$ come from doubly charged ions of mass 51 and 53. The small broad peaks are metastable ion transitions resulting from ions which dissociate after traversing the electric field. Hipple, Fox, and Condon (*6*) have studied and explained these metastable transition peaks.

The use of mass spectra for chemical analysis involves the direct comparison of the mass spectrum of an unknown with the spectra of pure compounds and an important project of the Mass Spectrometry Section is compiling mass spectra of pure compounds.

To show characteristics of the mass spectra of hydrocarbons it is convenient to use a greatly simplified picture in which only peaks greater than 2 percent of the maximum peak are included. The maximum peak is uniformly given a height of 100. First are shown spectra of saturated hydrocarbons of formula $C_n H_{2n+2}$. Fig. 2 shows some of these.

In methane the most probable process is ionization without dissociation. Ionization

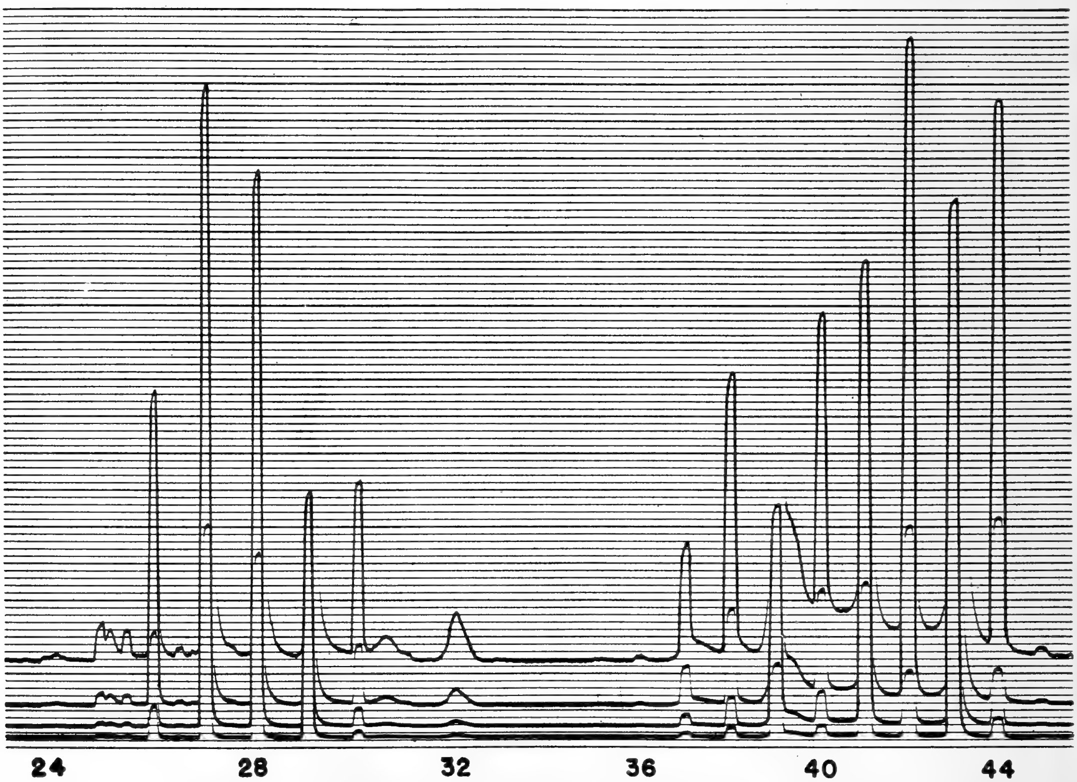


FIG. 1.—Part of the mass spectrum record of n-butane as obtained by a Consolidated mass spectrometer.

with removal of one hydrogen atom is probable but removal of H^+ is improbable and this is true in all hydrocarbons. In ethane the most probable ionization process involves removal of two hydrogen atoms. Production of CH_3^+ is relatively improbable here and in all hydrocarbons except methane. In propane and the two butanes loss of CH_3 is the most probable ionization process.

It is a useful property of the structure of saturated hydrocarbons that the parent peak of each hydrocarbon is characteristic of that hydrocarbon and can not be produced as a dissociation product of other compounds. The other mass peaks recur in spectra of heavier compounds. This is very convenient for the purpose of chemical analysis.

There are two isomers of butane and the different structures give markedly different spectra. One difference between n-butane and iso-butane is that one can not break iso-butane in half without first rearranging the hydrogen atoms. A peak at mass 29 is found so this rearrangement must occur before dissociation. Such rearrangements are common in more complicated molecules. The parent peak is much smaller in isobutane and it is a general rule that molecules with side chains have smaller parent peaks than the normal molecule.

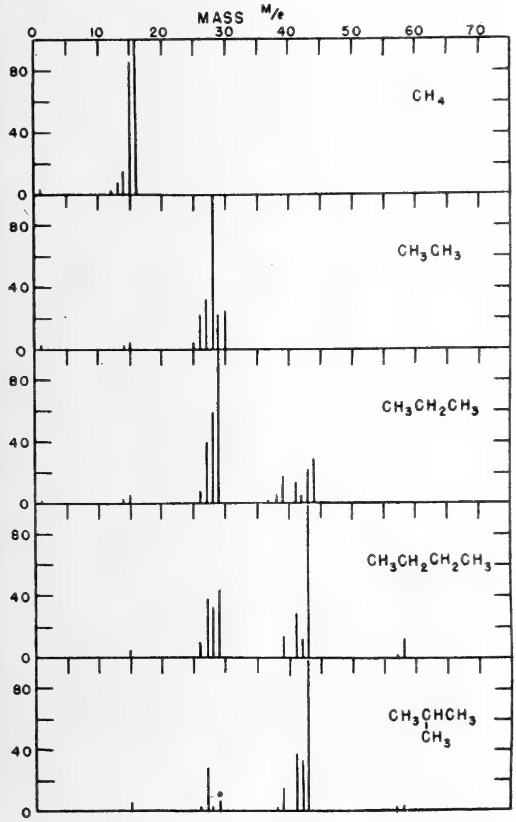


FIG. 2.—Mass spectra of methane, ethane, propane, and two butanes.

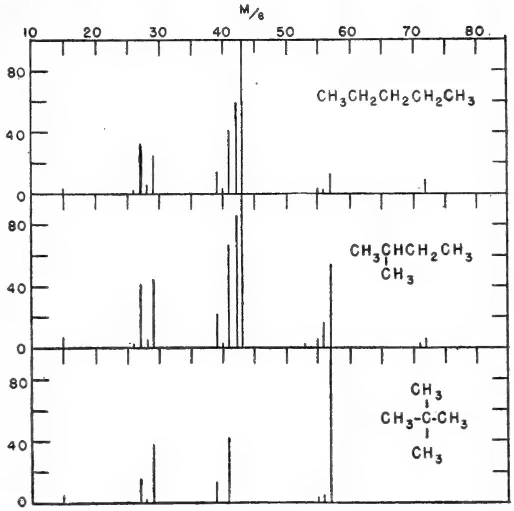


FIG. 3.—Mass spectra of pentanes.

Fig. 3 shows spectra of the three isomers of pentane. In normal and iso-pentane losing CH_2+CH_3 is the most probable process. In neopentane losing CH_3 is most probable and the parent peak is only a few hundredths of a percent. Losing two CH_3 radicals is quite improbable and the loss of CH_3+CH_4 involving breaking of three bonds is quite probable. The peak at $C_2H_5^+$ is large although this requires a rearrangement of hydrogen atoms before dissociation, as in iso-butane. Here the spectrum gives little clue as to the structure of the molecule.

There are five hexanes shown in Fig. 4 and these give five very different mass spectra. Many of the features of these spectra can be described qualitatively by the statement that there is a tendency to dissociate at either side of each side chain. Normal hexane like normal pentane loses C_2H_5 most readily. In 2-methyl-pentane, loss of one or three carbon groups is preferred, while in 3-methyl-pentane, loss of

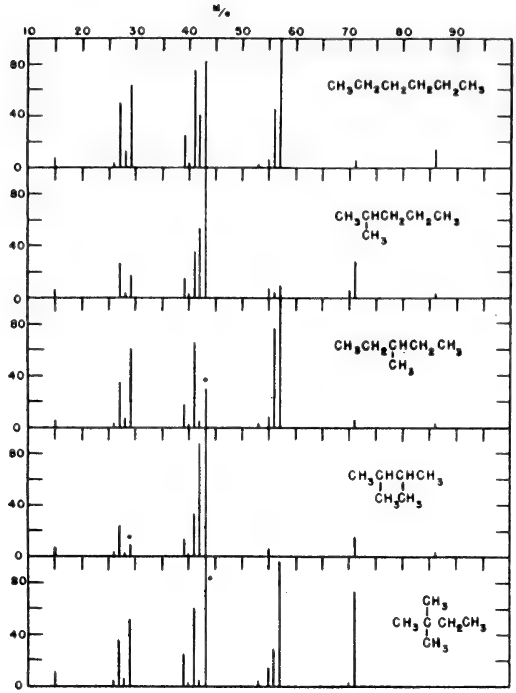


FIG. 4.—Mass spectra of hexanes.

C_2H_5 is again preferred. In 2,3-dimethyl-butane, loss of one and three are preferred while in 2,2-dimethyl-butane, one and two are preferred. In the last case, however, the most probable ionization process is breaking in half to give 43^+ although this involves a rearrangement of hydrogen atoms. Peaks involving rearrangement are also noted at 43 in 3-methyl-pentane and at 29 in 2,3-dimethyl-butane. We know that these cases involve rearrangement because the original structure does not yield such masses but obviously rearrangement may occur in other cases where it is indistinguishable from simple dissociation.

Our measurements include the nine isomers of the heptanes and the 18 octanes. All these show a great variety of mass spectra depending on the structure of the molecules. The tendency to dissociate on either side of a side chain is again found except in cases where rearrangements give ions which would not be expected on the basis of the molecular structure.

Fig. 5 shows some unsaturated molecules with double or triple bonds. In ethylene the parent peak is the maximum peak, while in ethane it is about 25 percent of the maximum. In acetylene the parent peak is by far the largest peak. In propylene the parent peak is not the largest, but the whole C three group of ions is much larger than in propane. Propylene always loses CH_3 rather than CH_2 and this is true of most of the unsaturated molecules. There are two isomers of C_3H_4, propadiene and methyl-acetylene, and their mass spectia are almost exactly alike in spite of the difference in structure. It seems very probable that in this case first a molecule ion is formed and then the hydrogen atoms are redistributed to give identical ions from both isomers.

Fig. 6 shows some unsaturated C four molecules. There are four butene isomers and they all give mass spectra similar to

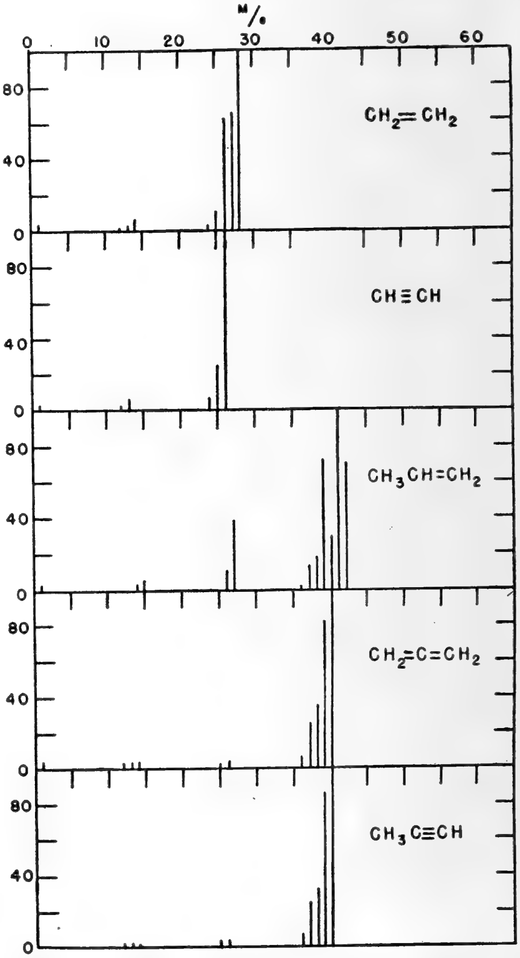
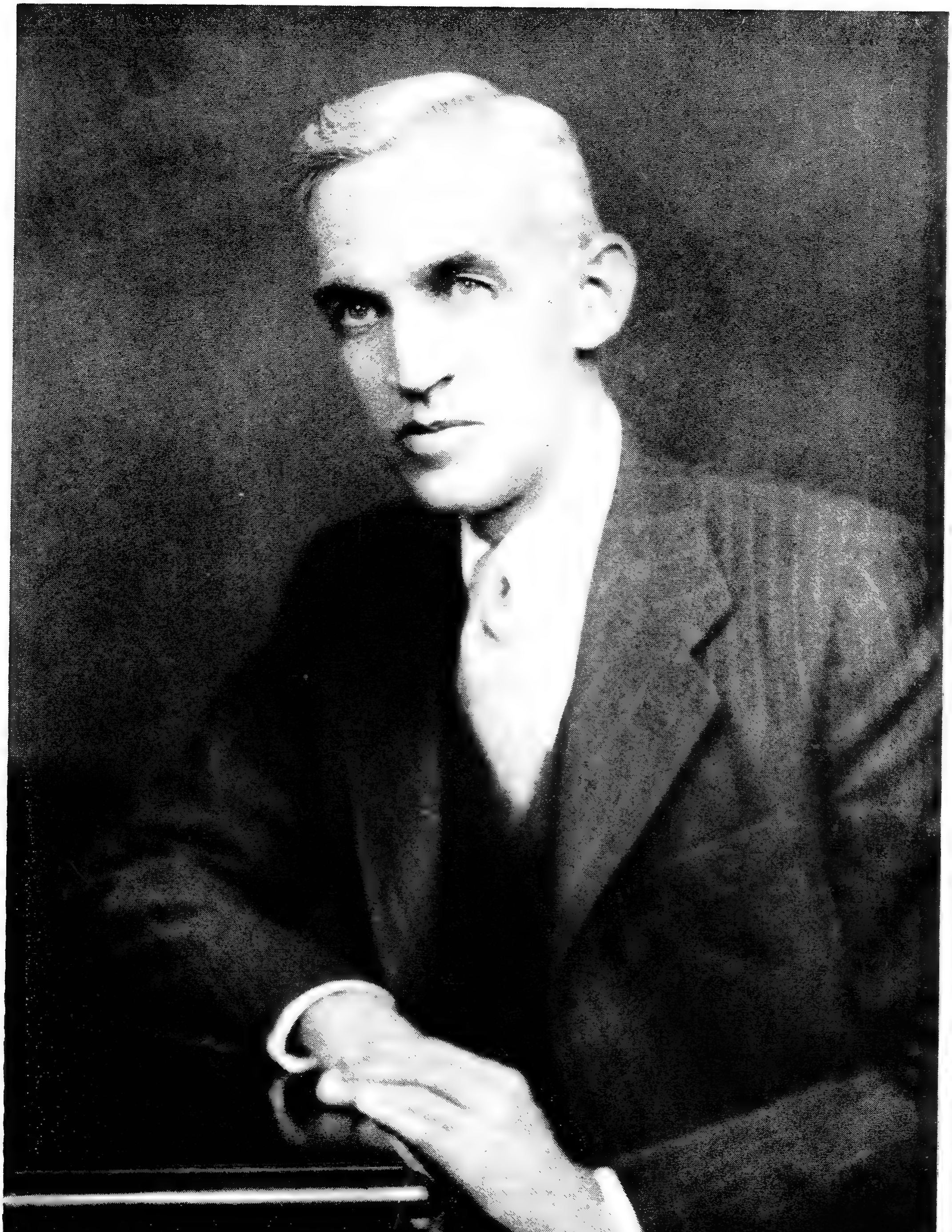


FIG. 5.—Mass spectra of ethylene, acetylene, propylene, propadiene, and methyl acetylene.



FRED L. MOHLER, president of the Philosophical Society of Washington, 1947

the 1-butene spectrum shown in the figure. 2-butene, $CH_3-CH=CH-CH_3$, has a cis and a trans form depending on whether the two central hydrogens are on the same side or opposite sides of the chain. The mass spectra are nearly identical, the most conspicuous difference being that the mass 29 peak is 15.5 percent of the maximum in the cis compound and 19.8 percent in the trans compound. These two molecules cannot give a 29^+ ion without a rearrangement of hydrogen atoms.

There are four isomers of C_4H_6 and the mass spectra show differences of a rather unexpected nature. The most probable ionization process in $CH_2{:}CH\cdot CH{:}CH_2$ is loss of mass 15 which involves a double dissociation while in the other isomers which can lose 15 in a simple dissociation this transition is less probable. Also, the mass 28 peak is largest in 1,3-butadiene where production of 28^+ involves a rearrangement of hydrogen atoms.

The unsaturated hydrocarbons show several characteristics as a class. The parent peaks are larger than for saturated compounds and larger for doubly unsaturated compounds than for mono-olefins. Ionization by loss of CH_2 is very improbable even where both terminal radicals are CH_2. Both properties reflect the fact that the unsaturated bonds are stronger than the saturated bonds. Mass spectra of unsaturated molecules are also much less sensitive to structural differences among different isomers than is the case with saturated molecules. This indicates that rearrangements of hydrogen atoms in the molecule ion occur more readily in the unsaturated molecules. It may seem surprising that there are any rearrangements in saturated hydrocarbons and it will be of interest to study mass spectra with deuterium substituted at one position in the molecule and see where it appears in the mass spectrum.

On the basis of momentum considerations it must be assumed that electron collisions always produce molecule ions and that these ions may be left in a highly excited state and subsequently dissociate spontaneously to give the great variety of ions observed in the mass spectrum. I have referred before to small wide peaks in the

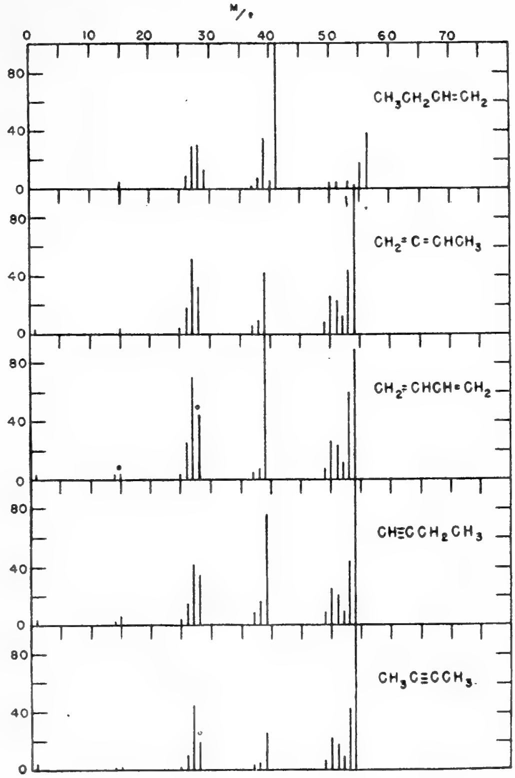


FIG. 6.—Mass spectra of butene-1, butadienes, and butynes.

mass spectrum that arise from ions which dissociate after they have traversed the electric field. Because of this phenomenon of delayed dissociation we can obtain direct experimental evidence as to some of the dissociation processes which occur.

The apparent mass m_a of an ion which dissociates immediately after traversing the electric field is

$$m_a = m_f^2/m_i$$

where m_i is the initial mass and m_f the final mass of the ion (*6*). Because the ions dissociate over a range of positions the peaks are wide. The dissociating ions are presumably metastable ions with a life of the order of 10^{-6} seconds (*7*). As m_f and m_i are integers equal to or less then the molecular weight the numerical value of m_a is sufficient to determine both m_f and m_i. An important aid in finding m_f and m_i is a qualitative intensity rule that the mass peaks corresponding to m_f and m_i are always fairly large peaks in the mass spectrum.

To return to Fig. 1, there are seven metastable transitions in the range of this record but some are very hard to see. The one at mass 32 comes from the parent ion of mass 58 losing mass 15, a CH_3 radical. The one near mass 30 comes from 58 losing CH_4. These two transitions only occur in n-butane. A large peak near 39 comes from 43^+ losing two hydrogen atoms and near 25 is a peak from 29 losing two hydrogens. These last two recur in many hydrocarbons.

Mrs. Bloom of our Section has made a careful compilation of mass spectra of 56 hydrocarbons and has found 362 cases of metastable transition peaks and has identified the transitions involved (*8*). The compounds include saturated hydrocarbons through C eights, mono-olefins through C fives, and four C_4H_6 isomers. The data have been published in the American Petroleum Institute Catalogue of Mass Spectral Data (*9*).

The transitions frequently recur in different hydrocarbons and 32 different transitions are found. These involve loss of masses ranging from 2 to 44. Table 1 summarizes the metastable transitions. Loss of mass 2 is by far the most common type of metastable transition and it appears in nearly all cases where there are two large peaks differing by two mass units. Losses of masses 1 or 3 are never observed.

It is also significant that there are no metastable transitions involving loss of CH_2 as this is a structural unit in most hydrocarbons and large peaks often fall at intervals of 14.

Loss of CH_3 is only observed from parent ions and is a comparatively infrequent phenomenon. CH_4 is not a structural unit and loss of 16 involves a double dissociation. The loss from the ion 57^+ recurs in 30 of the 40 saturated hydrocarbons.

Loss of C_2H_2 seems to be a unique property of the 55^+ ion and recurs in most of the hydrocarbons. The loss of C_2H_3 occurs only when the butadienes and butyne-2 split in half. It is of interest that the unsymmetrical molecule $CH_2=C=CH-CH_3$ splits in half although this requires a rearrangement before splitting. C_2H_4 in the form $CH_2 \cdot CH_2$ or $CH \cdot CH_3$ is a structural unit of many saturated molecules and the 2 metastable transitions recur in many of them. In this case, the terminal CH_3 radical must first be removed from the initial ion.

The loss of mass 29 comes from loss of the structural unit $CH_2 \cdot CH_3$ and includes the terminal radical as is shown by the fact that it comes from parent ions. Loss of mass 30 comes from losing two CH_3 radicals from the parent ion and necessarily involves a double dissociation.

The mass C_3H_6 can be $CH_2 \cdot CH_2 \cdot CH_2$ or can involve methyl side chains, but like C_2H_4 it will never come from parent ions. Of course, it can only come from rather large molecules. Loss of mass 44 from the parent mass of 3 heptanes is perhaps doubtful. We are not certain that there is not an alternative explanation. It involves a double dissociation, removal of mass 43 and one hydrogen.

This looks very complicated, and I have given it in detail to show that dissociation of ions does indeed involve many alternative processes. If the initial metastable ion is the parent ion this means that the molecule ion traverses the electric field and then dissociates. When the initial ion is not the parent ion then the dissociation takes place in at least two stages. The initial metastable

TABLE 1.—SUMMARY OF METASTABLE TRANSITIONS

Mass lost		Occurrence
2	2H	8 transitions in all hydrocarbons except methane.
15	CH_3	7 transitions from parent ions of 13 unsaturated and 5 saturated hydrocarbons.
16	CH_4	$55^+ \rightarrow 39^+ + 16$ in pentenes. $57^+ \rightarrow 41^+ + 16$ in 30 saturates. $58^+ \rightarrow 42^+ + 16$ in n-butane.
26	C_2H_2	$55^+ \rightarrow 29^+ + 26$ in 41 hydrocarbons.
27	C_2H_3	$54^+ \rightarrow 27^+ + 27$ in 3 isomers of C_4H_6.
28	C_2H_4	$71^+ \rightarrow 43^+ + 28$ in 21 saturates. $85^+ \rightarrow 57^+ + 28$ in 14 saturates.
29	C_2H_5	3 transitions from parent ions of pentenes, n-hexane, and 3 octanes.
30	C_2H_6	4 transitions from parent ions of 12 saturated hydrocarbons.
42	C_3H_6	$85^+ \rightarrow 43^+ + 42$ in 19 heptanes and octanes. $99^+ \rightarrow 57^+ + 42$ in 17 octanes.
44	C_3H_8	$100^+ \rightarrow 56^+ + 44$ in 3 heptanes.

ion is formed by dissociation within the ionization chamber, then it passes through the electric field and dissociates again. Sometimes large structural units are broken off in a single dissociation; in other cases at least two bonds must be broken in the delayed dissociation as in losing two CH_3 radicals or CH_4.

The metastable transitions account for only a small fraction of all the dissociations. Hipple (*7*) has made quantitative estimates in the case of n-butane. The parent ion gives rise to two metastable transitions with loss of masses 15 and 16. The life of each excited state is about 2×10^{-6} sec and initially at time zero not over 10 percent of the 58^+ ions are in the excited state or states which give rise to these transitions. Now the 58^+ ions account for only about 4 percent of all the n-butane ions. Ninety-six percent of all the ions dissociate immediately or very quickly, about 3.6 percent become stable 58^+ ions and 0.4 per cent fall into the metastable states. This is probably a typical case as far as orders of magnitude are concerned.

What I have said has been largely descriptive and probably seems like little more than a catalog of empirical facts. However, this is largely a matter of viewpoint. As I pointed out in the introduction, these mass spectra are a molecular property and are somewhat analogous to intensities in molecular absorption spectra but in absorption spectra there is a theoretical basis for the interpretation of results. In spite of all the work on mass spectra we still lack this theoretical background. This is not only a challenging problem but it is of considerable practical importance. Chemical analysis now depends on comparing unknowns with pure samples of the various components. It would be very useful if we could deduce the structure of pure compounds of unknown structure. Beyond C sevens the possibilities become so many that empirical methods can never give the complete answer.

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BOTANY.—*New species of* Achaetogeron (*Compositae*) *from Mexico*.[1] ESTHER L. LARSEN, Crown Point, Indiana. (Communicated by S. F. BLAKE.)

The new species here described were discovered some years ago when the genus *Achaetogeron* was being studied together with several related genera of the tribe Astereae. The work was done at the Missouri Botanical Garden. The following abbreviations are used for herbaria cited: M = Missouri Botanical Garden; NY = New York Botanical Garden; Phil = Academy of Natural Sciences, Philadelphia; US = U. S. National Herbarium.

Achaetogeron filiformis Larsen, sp. nov.

Annuus 15–45 cm altus; caules tenues juventate simplices maturitate diffuse ramosi foliosi patenti-hirsuti; folia obovata ad obovato-spathulata pinnatifida 0.5–4 cm longa, lobis obtusis apiculatis strigosis; folia suprema bracteiformia oblonga integra; pedunculi filiformes 1.5–2.5 cm longi infra capitulum dense patenti-hirsuti; capitula 0.7–1 cm diam.; phyllaria 2–3-seriata lineari-lanceolata acuminata glandulari-puberula basi hirsuta; radii albi vel caerulei supra discum arcte circinnati; pappus inconspicuus coroniformis laceratus, in floribus radii interdum etiam setis paucis donatus; achenia pubescentia pilis apice rectis vel obscure bidentatis.

TAMAULIPAS: Vicinity of Tampico, alt. 15 m, March 10–April 19, 1910, *E. Palmer* 249 (type, M, also US); vicinity of La Barra, 8 km east of Tampico, at sea level, February 1–8, 1910, *E. Palmer* 281 (M, US); en route

[1] Received March 23, 1948.

from San Luis Potosí to Tampico, December 1878 to February 1879, *E. Palmer* 1089 (US). VERACRUZ: Vicinity of Panuco, April 20–25, 1910, *E. Palmer* 356 (US).

The filiform peduncles, small heads, and circinate rays which scarcely exceed the disc distinguish this species.

Achaetogeron fisheri Larsen, sp. nov.

Herbaceus 20–45 cm altus ubique strigosus, ramis adscendentibus e caule decumbente sublignoso; folia caulina sessilia alte pinnatisecta 1–3 cm longa lobis 3–7 lineari-lanceolatis obtusis, folia suprema saepius integra linearia; pedunculi 2–4 cm longi strigosi; capitula 2–2.5 cm diam. (radiis inclusis); involucri 2–seriati 0.5 cm alti phyllaria lineari-lanceolata acuminata glanduloso-puberula et strigosa, margine scariosa; pappus annularis laceratus inconspicuus cum setis caducis interioribus; achenia basi callosa pubescentia; pilis bidentatis.

STATE OF MEXICO: Amecameca, alt. 2,648 m, July 29, 1924, *Fisher* (M, No. 914802 type); Amecameca, alt. 2,676 m, July 29, 1924, *Fisher* 220 (US). PUEBLA; Teutla, October 1913, *Salazar* (US); Manzanilla, vicinity of Puebla, November 24, 1908, *Arsène* 10184 (US).

The subpinnatifid leaves and a pappus crown so reduced as to be nearly lacking are characteristic.

Achaetogeron sophiaefolius Larsen, sp. nov.

Perennis 30–60 cm altus; caules plures e basi sublignoso ramosi striati patenti-hirsuti et subglandulari-puberuli; folia elliptica ad ovata, pinnatisecta vel bipinnatisecta inferiora petiolata usque ad 9 cm longa pilis longis multicellularibus appressis pubescentia et minute glandulari-puberula, segmentis ultimis obtusis, superiora sensim reducta sessilia, suprema bracteiformia; pedunculi 1.5–3 cm longi dense appresse pubescentes; capitula terminalia solitaria 2–2.5 cm diam. (radiis inclusis); involucri 1–1.2 cm diam. phyllaria 2-seriata 4 mm longa lineari-lanceolata acuminata glandulosa et parce hirsuta pilis multicellularibus, margine membranacea; pappus minutus coroniformis laceratus cum setis paucis caducis interioribus; achenia basi callosa pubescentia pilis apice rectis vel dentatis.

DURANGO: City of Durango and vicinity, April–November 1896, *E. Palmer* 158 (M, No. 123017 type, NY, US).

A relatively coarse plant with conspicuously bipinnatisect leaves, which are pubescent with long appressed multicellular hairs.

Achaetogeron pringlei Larsen, sp. nov.

Herbaceus erectus ca. 65 cm altus ubique glandulari-puberulus et patenti-hirsutus; folia caulina sessilia alte pinnatisecta lobis ca. 5–9 linearibus vel lineari-spathulatis obtusis utrimque sparse villosa margine ciliata; folia inflorescentiae lineari-lanceolata integra vel interdum lobata sensim reducta, suprema ca. 1 cm longa; pedunculi 1.5–2.5 cm longi dense glandulari-puberuli pilis sparsis intermixtis; capitula 1.5–2.5 cm diam.; involucri 2-seriati phyllaria lineari-lanceolata acuminata anguste membranaceo-marginata glandulari-puberula et sparse pilosa; radii numerosi albi saepe reflexi; flores disci numerosi; pappus minutus coroniformis laceratus cum setis paucis interioribus caducis; achenia anguste obovata basi minute callosa pubescentia pilis apice rectis vel bidentatis.

CHIHUAHUA: Cool slopes, Sierra Madre, October 10, 1888, *Pringle* 1625 (M, type); cool slopes, foothills of the Sierra Madre, October 11, 1887 *Pringle* 1272 (Phil). PUEBLA: Santa María de Zacatepec, vicinity of Puebla December 1908, *Arsène* (US).

Distinguished by deeply pinnatisect, sparingly villous leaves and a relatively finer habit than *A. sophiaefolius*.

Achaetogeron polycephalus Larsen, sp. nov.

Herbaceus lm altus et ultra (basi inviso) ubique strigosus et minute glandulari-puberulus; caulis supra valde ramosus aetate glabratus; folia caulina majora oblanceolata sessilia prope apicem serrata usque ad 5 cm longa 1.5 cm lata, minora valde reducta integra; pedunculi 1–4 cm longi striati strigosi et minute glandulari-puberuli; capitula 2–3 cm diam. (radiis inclusis); involucri 2-seriati phyllaria lineari-lanceolata acuminata anguste membranaceo-marginata minute glandulari-puberula basi patentipilosa margine angusto membranaceo leviter lacerato; radii numerosi albi; pappus minutus annularis laceratus cum paucis setis interioribus; achenia basi callosa dense pubescentia pilis apice rectis vel bidentatis.

DURANGO: San Ramón, April 21–May 18, 1906, *E. Palmer* 52 (M, type).

A profusely branching, strigose-pubescent

plant with serrate leaves and many scattered heads.

Achaetogeron corymbosus Larsen, sp. nov.

Herbaceus 20–40 cm altus dense breviterque cinereo-hirsutus et minute glandulari-puberulus; caules erecti ramosi ramis apice corymboso-ramosis; folia caulina oblanceolata sessilia supra serrata 5 cm longa 1.5 cm lata, superiora ad bracteas sensim reducta; folia infima non visa; pedunculi 0.5—1 cm longi; capitula 1–1.5 cm diam. (radiis inclusis); involucri 2-seriati phyllaria lineari-lanceolata acuminata minute glandulari-pubescentia et sparsissime hirsuta, margine angusto scarioso leviter lacerato; radii albi; pappus minutus coroniformis vel annularis laceratus cum setis paucis caducis interioribus; achenia basi late callosa dense pubescentia pilis longis apice rectis.

JALISCO: Canyons, moist rocks, Tuxpan, February 1904, *Purpus* 527 (G, type).

The serrate leaves, crowded corymbs, and cinereous aspect are characteristic.

Achaetogeron garciae (Blake) Larsen, comb. nov.

Bellis garciae Blake, Contr. U. S. Nat. Herb. **22**: 593. 1924.

Still known only from the type, *P. Ibaña García* 310 (U. S. Nat. Herb. 1032782) from the State of Durango, alt. 100 m.

ENTOMOLOGY.—*Notes and descriptions of Nearctic Hydroptilidae (Trichoptera).*[1]

HERBERT H. ROSS, Illinois Natural History Survey, Urbana, Ill.

In the caddisflies of the family Hydroptilidae there undoubtedly exists a number of genera that bear their closest relationship with forms known from other regions and with which they have not yet been associated. Two such cases are outlined in this paper, and in each the geographic limits of the genera involved are extended into another continent. During the investigation of these cases some interesting morphological considerations have arisen, and as a result a few suggestions regarding terminology are made in this paper.

I am greatly indebted to Dr. G. T. Riegel, University of Illinois, and to Dr. H. K. Gloyd, Chicago Academy of Sciences, for making material available to me for study, and to Dr. D. G. Denning for the loan of type material of some of the species studied. Types of new species described in this paper are deposited in the collection of the Illinois Natural History Survey.

TERMINOLOGY

In reviewing the terminology I have used for parts of the male genitalia of Hydroptilidae, one change and one addition seem indicated in the interests of clarity and structural identification.

Subgenital plate.—In most genera of Hydroptilidae there is a variously shaped, mesal structure usually occurring above or between the claspers. In *Hydroptila*, Fig. 6, *sp*, and *Neotrichia* this structure is platelike and bears at its apex a pair of setae. In *Oxyethira* and *Stactobiella* what appears to be this same structure is heavily sclerotized, frequently arched, and assumes a variety of shapes in different species; in these two genera I have heretofore called this structure the tenth tergite (Ross, 1938, 1944). The tenth tergite, however, must be above the aedeagus, whereas in the structure in question, Fig. 1*A*, *sp*, it is situated below the aedeagus. It may be a sort of guide for the aedeagus or it may assist in the coupling action during copulation. Because it lies below the aedeagus and because its exact homology is obscure, I am proposing that this plate be called the *subgenital plate.*

Bracteole.—In quite a number of Hydroptilidae, especially in *Stactobiella*, there occurs a structure associated with the area dorsad of the base of each clasper. In some cases, Fig. 1, *br*, this appears as a small structure at the base of each clasper, in others, Fig. 2, *br*, the structure is larger and more conspicuous than the clasper and probably usurps its function. For this I propose the term *bracteole.* Here again the homology is difficult to determine, but I believe that the term will be a useful one for purposes of taxonomic description.

[1] Received March 8, 1948.

Genus **Stactobiella** Martynov

Stactobiella Martynov, Pract. Ent. **5**: 58. 1924. (Genotype, monobasic, *Stactobia ulmeri* Siltala.)

Tascobia Ross, Bull. Illinois Nat. Hist. Surv. **23**: 124. 1944. (Genotype, by original designation, *Stactobia palmata* Ross.) *New synonymy.*

Comparing Nearctic species of this genus with illustrations of Palearctic species shows that not only are the two genera synonymous but also that two Nearctic forms each have their closest known relative in the Palearctic fauna. *S. palmata* (Ross) is very similar to Martynov's illustrations of *biramosa* Martynov, the former having the claspers short and ovate, constricted at base, and the stalked process tridentate, the latter having the claspers slightly longer and parallel-sided, and the stalked process bidentate. In each the aedeagus is simple and tubular. The Nearctic species *delira* (Ross) is similar to the Palearctic *ulmeri* (Siltala) and *risi* (Felber), especially in regard to the curved, fingerlike subgenital plate, but exhibits marked differences in the shape of each structure. The Nearctic *brustia* Ross is not allied closely to any of the other species and forms a species complex of its own. Thus, not only is *Stactobiella* as a genus Holarctic in distribution, but two of its three component phylogenetic units are truly Holarctic also.

To assist in identifying these species, a key is given to the males of these six species, which comprise the known world fauna of the genus. I have taken characters of the Palearctic forms from illustrations in the literature, cited in the key.

KEY TO SPECIES OF STACTOBIELLA MALES

1. Claspers apparently fused to form a ventral plate bearing three whiskerlike brushes of setae; aedeagus with apex curved and bent into shape of a crook (Ross, 1938, p. 115, fig. 22). Nearctic (Wyoming) . . . . *brustia* (Ross)
   Claspers not fused, either elongate or biscuit-shaped 2
2. A curved process, the bracteole, arising above each clasper, longer than the clasper and divided at apex into two or three fingerlike branches, Fig. 2; subgenital plate short and wide 3
   Bracteole represented by only a small process associated with a lateral clump of setae, clasper long, parallel-sided or tapering to apex; subgenital plate long and fingerlike, often curved or angled, Fig. 1 4
3. Bracteole having apex divided into two "fingers" (Martynov, 1934, p. 159, fig. 105). Palearctic (Russia) . . . . . *biramosa* Martynow
   Bracteole having apex divided into three "fingers," Fig. 2. Nearctic (central U. S. A.) . . . . *palmata* (Ross)
4. Apical portion of aedeagus divided into one mesal and two lateral lobes, Fig. 1*A*. Nearctic (northcentral U. S. A.) . . . . . *delira* (Ross)
   Apical portion of aedeagus tubular, much as in Fig. 2 5
5. Apical margin of clasper truncate and slightly oblique (Felber, 1908, p. 721, fig. 2). Palearctic (Switzerland) . . . . *risi* (Felber)
   Apical margin of clasper rounded, the clasper tip narrow (Martynov, 1934, p. 159, fig. 103). Palearctic (northern Europe) . . . . *ulmeri* (Siltala)

Genus **Oxyethira** Eaton

Argyrobothrus Barnard, Trans. Roy. Soc. South Africa **21**: 392. 1934. (Genotype, monobasic, *A. velocipes* Barnard.) *New synonymy.*

Barnard's illustrations of pupal case, venation, and genitalia of both sexes leave no doubt that *Argyrobothrus velocipes* is a typical member of *Oxyethira*. The genus as such has not been recorded previously from central or southern Africa.

Oxyethira arizona, new species

The wide, curved lateral process of the aedeagus and the long, ventral internal projection of the base of the ninth segment show a relationship of this species with *pallida* (Banks) and *maya* Denning, but *arizona* differs from both of these in the straight apical portion of the aedeagus (this part is angled and twisted in *pallida* and *maya*) and the elongate lateral processes of the eighth tergite.

Male.—Length from front of head to tip of wings, 2.5 mm. Color entirely pallid or straw color, with an annulation of a darker shade on some segments of the antennae and some darker areas on the front wings. General structure typical for genus. Seventh sternite with a sharp curved apical process. Genitalia as in Fig. 4. Eighth tergite divided into a pair of lateral lobes, the lower margin of each produced into a long, smooth, sharp process, the left one curved dorsad at tip, as shown, the right one curved slightly ventrad; the base of each lobe bears abundant long setae, but the projecting portion is without vestiture. Eighth sternite forming the lateral and ventral part of a ring, trapezoidal from lateral view, the apical margin gently curved on the meson. Ninth tergite membranous. Subgenital plate moderately

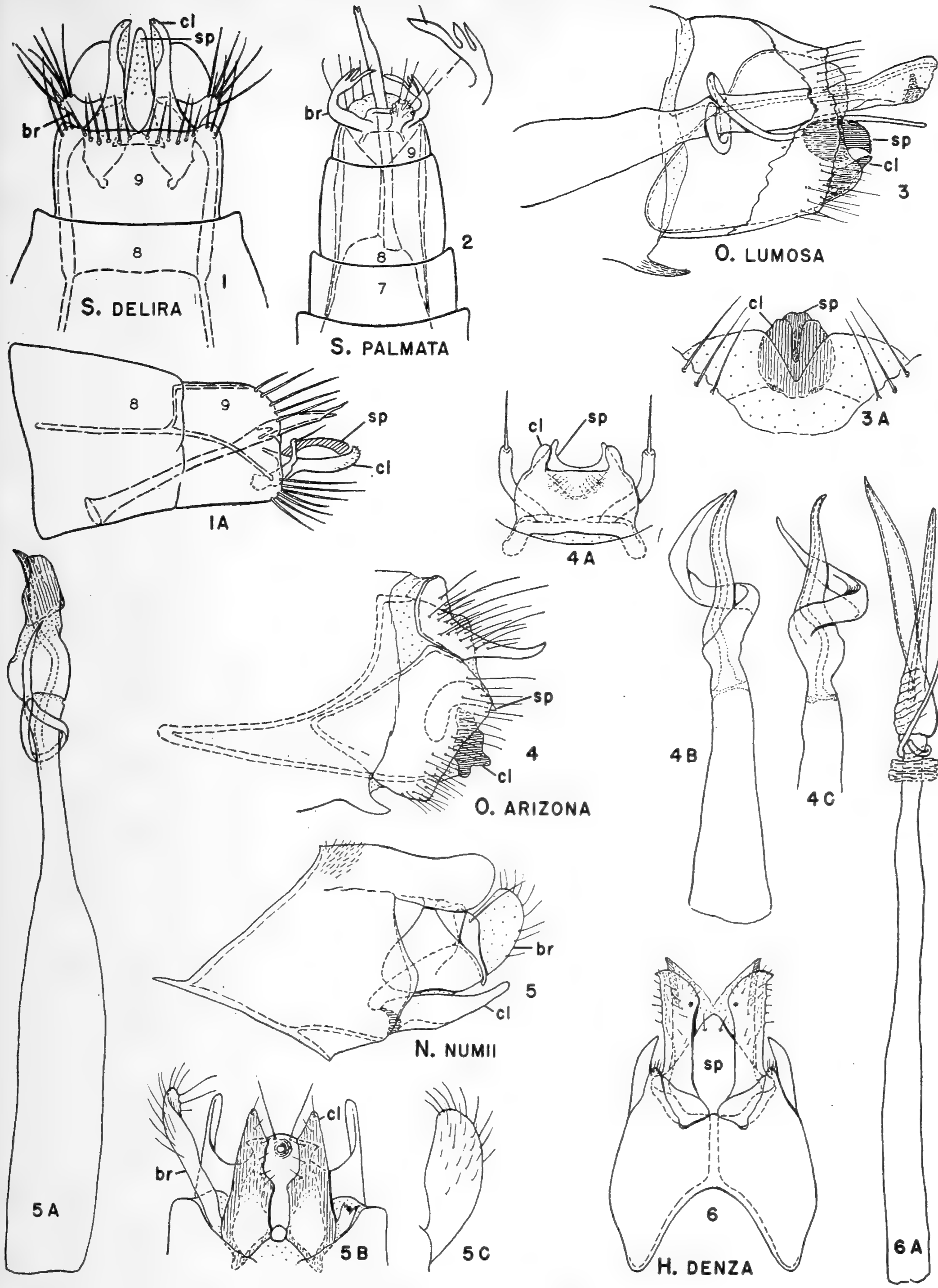

FIG. 1.—*Stactobiella delira*, male genitalia, ventral aspect; 1*A*, same, lateral aspect. FIG. 2.—*Stactobiella palmata*, male genitalia, ventral aspect. FIG. 3.—*Oxyethira lumosa*, male genitalia, lateral aspect; 3*A*, apical portion of male genitalia, ventral aspect. FIG. 4.—*Oxyethira arizona*, male genitalia, lateral aspect; 4*A*, claspers and associated structures, ventral aspect; 4*B* aedeagus; 4*C*, aedeagus as seen at right angles to long axis of 4*B*. FIG. 5.—*Neotrichia numii*, male genitalia, lateral aspect; 5*A*, aedeagus, 5*B*, claspers and associated structures, ventral aspect; 5*C*, bracteole. FIG. 6.—*Hydroptila denza*, male genitalia, ventral aspect; 6*A*, aedeagus. Abbreviations: *br*, bracteole; *cl*, clasper; *sp*, subgenital plate.

heavily sclerotized, lateral aspect evenly curved to form about a quarter of a circle, ventral aspect, Fig. 4*A*, incised at apex to form a mesal arcuate area on each side of which is a short fingerlike process. Claspers fused on meson, very deep dorsoventrad, the ventral apical margin bearing a fingerlike projection on each side with a truncate edge between them. Style sinuate, membranous, and tipped with a long seta. Aedeagus, Figs. 4*B* and *C*, with base only a little longer than apex; neck only indistinctly set off: and apex divided at base into a tapering, slightly twisted central portion bearing the penis, and a wide, ribbonlike twisted process which makes a complete circle around the central portion, and which is concave on its inside surface.

Female.—Size, color, and general structure similar to male. Genitalia simple; tenth tergite fairly wide at base, tapering to a round apex; ninth tergite with a narrow, spiculate, dorsoapical hump and with straight internal apodemes. Spermatheca and its associated structures similar in most respects to *pallida*, but differing in having the ventral bar of the spermatheca arcuate but only moderately wide.

Holotype, male.—Superior, Pinal County, Ariz., taken at light in Boyce Thompson Arboretum, May 17–24, 1946.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 2 ♂, 9 ♀.

Oxyethira pallida (Banks)

Oxyethira cibola Denning, Can. Ent. **79**: 12. 1947. *New synonymy.*

The most outstanding character of this species is the more slender of the two curved lateral processes of the aedeagus. This is absent in *maya* Denning; the other apical structures of the aedeagus are subject to twisting in both species and, in comparably twisted specimens, are remarkably similar in both.

Collecting generously afforded by Dr. Swingle around artificial fish ponds near Auburn, Ala., brought in several catches of this species. It is probable that it is the first species of caddisfly to invade these ponds after they are filled.

Oxyethira lumosa, new species

This species is most closely related to *grisea* Betten and *novasota* Ross on the basis of simple eighth segment and the long, curled spiral process of the aedeagus. From both species and others in the genus it differs markedly in the small, compact, ovate ventral aspect of claspers and subgenital plate, Fig. 3*A*.

Male.—Length from front of head to tip of wings, 2.5 mm. Color a salt and pepper mixture of cream and brown. General structure typical for genus. Seventh sternite with a sharp apicomesal spur. Genitalia as in Fig. 3. Eighth segment almost cylindrical, the apical margin slightly roughened and its ventral aspect U-shaped. Ninth segment with ventral portion forming only a rounded internal lobe extending only slightly into the seventh segment. Ninth segment also having no prominent marginal structures, the dorsal portion membranous and the ventral portion membranous and emarginate to form a deep V around the base of the claspers. Subgenital plate with lateral aspect forming a stout, hook-shaped structure with a wide base and stout, curved apex with a sharp tip, and with ventral aspect ovate and slightly incised on meson. Claspers fused to form an ovate plate deeply incised on meson from apex to over half the distance to base, Fig. 3*A*. Aedeagus not very long, base only about as long as apex, and the neck indicated by a shallow constriction and the origin of the spiral process. This structure is stout and long, and encircles the aedeagus one and a half times, the first circle making almost a ring and the other half circle made while extending posteriad to the apex of the aedeagus. Apex of aedeagus cylindrical, semimembranous, and with a sclerotized, sharp, triangular sclerite placed transversely across the structure near the tip.

Holotype, male.—Daytona Beach, Fla., August 27, 1945, G. T. Riegel.

Genus **Hydroptila** Dalman

This is the most abundant and widespread genus of Hydroptilidae, with species known from every part of the globe. It is interesting that the Nearctic fauna contains many species whose closest relatives are in the Palearctic fauna, and other species which have apparently arisen from Neotropical nuclei of evolving forms. The species described below is of this latter category.

Hydroptila denza, new species

Among some material from Mexico a speci-

men was encountered that is of the general type of *meralda* Mosely, but differs from it in a variety of characters: The claspers are little longer than the subgenital plate, the apex of the tenth tergite is deeply incised, and the apical blades of the aedeagus are wide and swordlike, Fig. 6*A*.

Male.—Length from front of head to tip of wings, 3 mm. Color moderately dark brown, the wings mottled with gray and brown. General structure typical for genus and scent cap ovate. Seventh sternite with a short, sharp apicomesal process. Genitalia as in Fig. 6. Ninth segment projecting freely from eighth segment, its internal portion rounded and only moderately produced, the apicolateral margin bearing a fingerlike lobe which appears sharp and spurlike from ventral view. Tenth tergite with lateral margins sclerotized, mesal portion membranous and deeply incised. Clasper of moderate length, ventral aspect with apex slightly widened, lateral aspect with apex much widened and trianguloid; apicolateral corner projecting as a small sharp point, apicomesal corner slightly angulate and a small sclerotized point just within it. Subgenital plate triangular, over two-thirds as long as clasper, and bearing a pair of setae near apex. Aedeagus, Fig. 6*A*, with base extremely long, extending internally through three full segments of a completely extended specimen; neck bearing a rufflike collar of membranous folds and a slender spiral process which encircles the aedeagus one and a half times; base of apex swollen, the apex beyond this divided into two parts, a long, bladelike, flattened, sclerotized process, and a tapering, straight style which bears the penis tube and which is membranous and corrugated at its base.

Holotype, male.—Hacienda Santa Engracia, Tamaulipas, Mexico, March 9, 1939.

Genus **Neotrichia** Morton

As is true of *Ochrotrichia, Mayatrichia,* and a few other genera, additional United States species of *Neotrichia* continue to follow patterns of general structure found in Central American forms. To date these genera are known only from the New World, and their distribution seems to indicate clearly that these genera originated in the Neotropics, and various species are spreading northward following the retreat of the glacial area.

Neotrichia numii, new species

The elongate and triangular claspers and the structure of the aedeagus indicate definite affinities between this species and *digitata* Mosely on the one hand and *collata* Morton on the other. From both this species differs in the extremely long, beaklike process of the subgenital plate, and the very dissimilar sclerotized processes at the apex of the aedeagus.

Male.—Length from front of head to tip of wings, 2.5 mm. Color entirely dark brown, the legs paler. General structure typical for genus. Genitalia as in Fig. 5. Ninth segment having an angulate internal portion, each side ending in a spurlike process; the dorsal portion is fused with the tenth tergite, the lateral portion is large and its apical margin is produced into a low, wide angle. Tenth tergite moderately narrow, rounded at apex and forming a simple, undivided mesal structure projecting above the other apical parts of the genitalia. Clasper elongate, lateral aspect tapering and curved at apex, ventral aspect having a broad, parallel-sided base narrowing suddenly to a short, pointed apex, heavily sclerotized and bearing only a few short setae. Bracteole, Fig. 5*C*, spatulate, pale, and bearing a series of long hairs on its ventral and apical margin, the base of the bracteole short and narrow, the apical portion broad and slightly curved dorsad. Subgenital plate unusually complex; the mesal portion, Fig. 5*B*, ends in a long beak which in lateral view is narrow and sharp, and in ventral view is expanded at apex into a platelike area bearing a hooked lateral process and a pair of mesal setae; this mesal part is joined ventrad with a large, convex lateral sclerite which narrows dorsad and appears to fuse with the inner margin of the tenth tergite. Aedeagus, Fig. 5*A*, elongate, the base tubular and narrowing to a long neck from the apex of which arises a stout spiral process encircling the aedeagus a little more than a complete turn; apex swollen at base, and divided at apex into a sharp spur bearing the penis and a lateral plate that is broad at base, slightly narrower at apex, and almost truncate at tip.

Holotype, male.—Lake George, Colo., in 11-mile canyon of the South Platte River, August 8, 1943, J. A. and H. H. Ross.

Neotrichia vibrans Ross

Neotrichia ranea Denning, Can. Ent. **79**: 20. 1947. *New synonymy.*

Further study of this species indicates that there is considerable lateral movement of several parts of the genital capsule, and that this may result in considerable difference of appearance between one specimen and another. The widely expanded condition is shown in my own drawing (Ross, 1938, p. 120, Fig. 29), and a more contracted condition is illustrated by Denning in the description of *ranea*. Dr. Denning has kindly loaned me his type material for study.

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ZOOLOGY.—*An analysis of specific homonyms in zoological nomenclature.*[1]

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In the systematic study of animals, which is the science known as systematics or taxonomy, the scientific names of the animals are at once an essential tool and a source of much confusion and discussion because of their vast number and the complexity of our system of using them. A branch of systematics has grown up which concerns itself entirely with these names and the principles to be used in applying them; this is nomenclature. Its principal aims are to formulate and establish systems under which each species can be given a distinctive name and to provide machinery to insure as great stability or permanence as possible to each of these names.

One of the difficulties which plague the taxonomist in his use of scientific names is the situation that arises when the same name is inadvertently given to two different species of animals. If a name is to be useful in exact science it must always refer to but one species, and always to the same species. Therefore, we cannot permit the use of one name for two or more species, and when duplicate names are found we must provide another name for one of the species. Identical names used for two or more species are called homonyms. They may be further classified by calling the older of the two usages the senior homonym and the younger one the junior homonym.

[1] Received April 2, 1948.

The discovery of homonyms very often results in a change of name for one of the species, and this type of change accounts for a large proportion of the annoying alterations of names that have given taxonomy a bad reputation among biologists. It is thus of special importance to taxonomists to study the problem of homonymy and find a way to protect names from this major source of instability.

The treatment of homonymy of specific names in zoological nomenclature is one of the oldest problems with which the writers of rules of nomenclature have had to deal, and it is one that has not been solved on any universal basis even after 75 years of code-building. It is therefore not unreasonable to reexamine the problem to present a possible new approach.

In the various nomenclatural codes that have been proposed, the treatment of the problem of homonymy differs widely. The reason for this divergent treatment is not clear, except on the assumption that none of them have given real satisfaction. It is therefore believed useful to examine the procedures that have been proposed heretofore and to analyze the requirements of a satisfactory system.

(I) The first method we will examine for dealing with homonyms is that prescribed by the International Rules of Zoological Nomenclature in articles 35 and 36. It is

the most direct and the simplest approach but may not be the one giving the most desirable results. This treatment is based on two principles: (1) "A specific name is to be rejected as a homonym when it has previously been used for some other species or subspecies of the same genus" (from article 35), and (2) "rejected homonyms can never be used again" (from article 36).[2] This is a simple and direct solution, and it has been reinforced by Opinion 83. Unfortunately the ramifications of nomenclature are not as simple as this rule, and names do not conform to a pattern of being irrevocably either "homonyms" or "not homonyms" at any given time.

This can be illustrated by diagrams of the eight major types of homonyms (Fig. 1). You may recognize in these diagrams your old friends *X-us albus* and *Y-us albus*. In these diagrams two genera are represented in parallel vertical columns. The passage of time as one reads down each diagram is indicated by the dates at the left, and the

[2] The term specific name is here used in its currently official meaning, in which the combination of the generic and the trivial names is a specific name. Article 2 holds that the scientific designation of a species is binomial, and it is therefore only the binomial combination that can be a homonym.

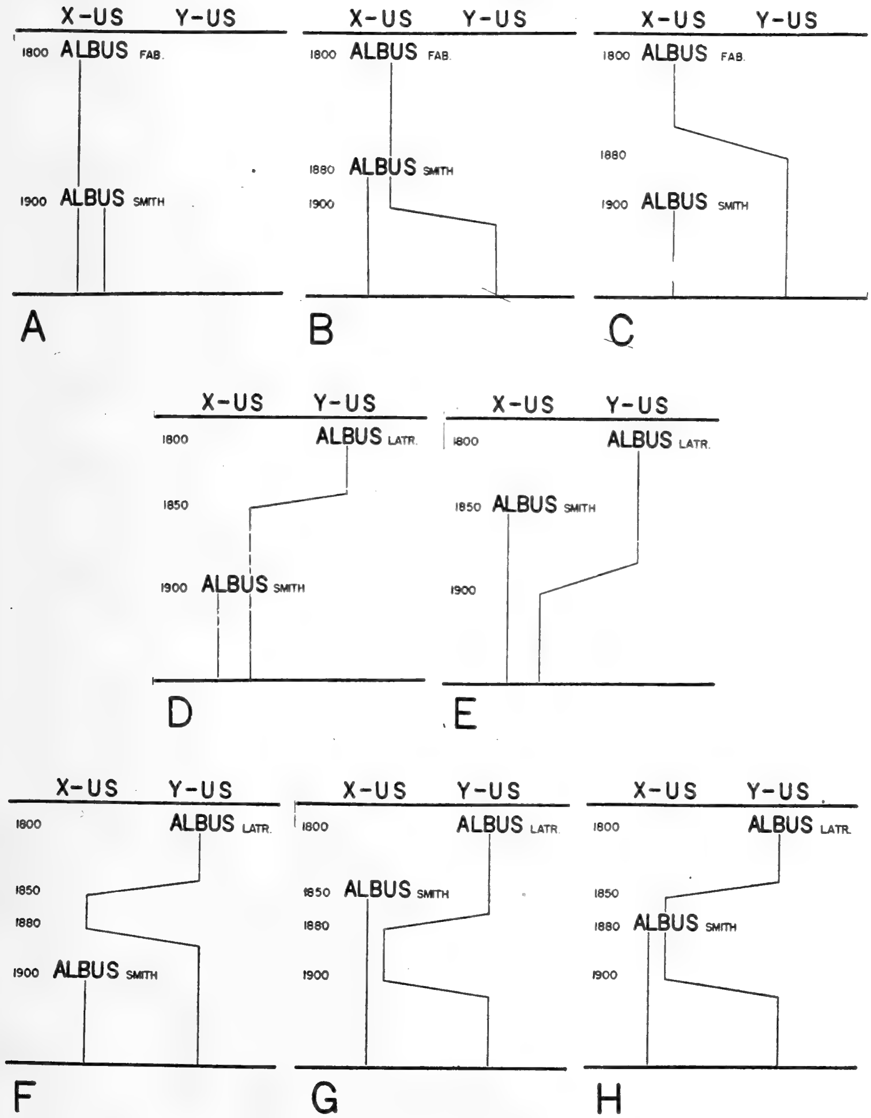

FIG. 1

subsequent history of each specific name is indicated by the solid line beneath it. The heavy horizontal line at the bottom represents the time at which the homonymy is discovered. In A, *albus* was proposed twice in *X-us*, producing unequivocal homonymy from 1900 on. B is just like A except for the later removal of one of the species to *Y-us*. It would be just the same if it had been the other name that was removed. In C the older name has been removed before the proposal of the second name. In D the two were originally proposed in separate genera, but by the time the second was proposed in *X-us*, the older name had been transferred to *X-us*, producing unquestionable homonymy. E is similar except that the transfer of the older name is later than the proposal by Smith. And F, G, H are the same as D and E except that the transfer of the older name to *X-us* was temporary—in F entirely prior to Smith, in G entirely subsequent to Smith, and in H partly before and partly after Smith.

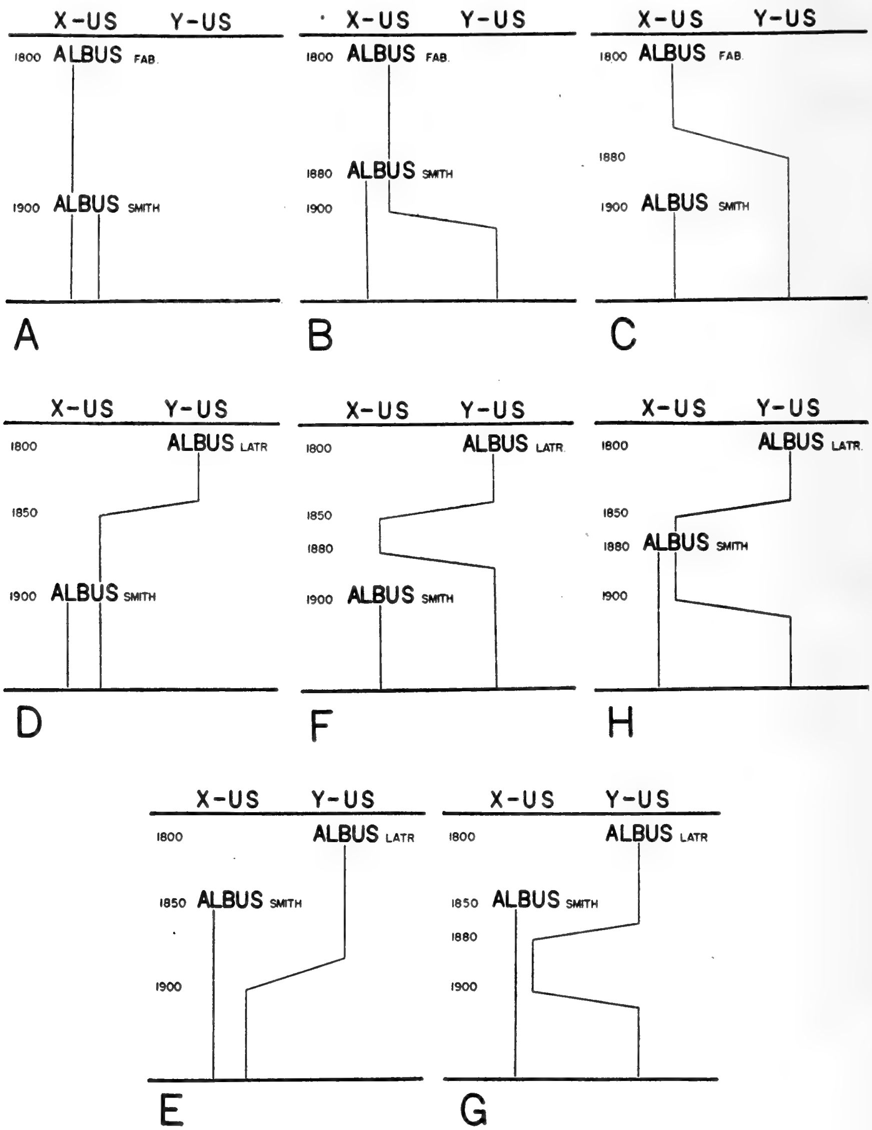

FIG. 2

Under the International Rules every one of these eight types of homonyms requires a change of name, because in every case there has been combined with *X-us* a name *albus* that is older than *X-us albus* Smith 1900. This is the rigid interpretation of the present wording of the Rules, which has been followed by many taxonomists but by no means by all.

Many taxonomists have felt that in some of these cases, such as diagram F in which the homonymy was of a temporary historical nature, it is not really necessary to replace the 1900 name. They have argued that a distinction of some sort should be made to prevent the change of such names.

(II) The question of whether all homonyms should be treated alike has led to wide discussion of a possible distinction between two types called primary and secondary homonyms, so that different treatment might be accorded them after revision of this part of the Rules. There have been at least two definitions of primary and secondary homonyms, but the one most commonly known is this. A homonym is primary if the names were originally proposed in the same genus; it is secondary if the two names occur in the same genus only through transfer of one from another genus. It is argued that all primary homonyms must be replaced, but that secondary homonyms should require replacing only if the names are still in the same genus. The examples in the top row of Fig. 1 (A, B, C) are primary, since the names were originally in the same genus; all the rest are secondary, under this definition, because the names were originally in different genera. A, B, C require replacing of the younger name, since these are primary homonyms, but D and E also require replacing, because both names are currently in use in *X-us*. Only F, G, and H can be saved by this procedure. Stability of the names is indicated by a tabulation, thus:

Method	*Change*	*Keep*
I. International Rules	8	0
II. Primary-Secondary (original genus)	5	3

(III) A third school employs primary and secondary in a very different sense. Here, a homonym is primary if it was a homonym at the time of its proposal, whether this fact was recognized or not; it is secondary if it was valid when proposed and became a homonym later by other action.

Again, the primary homonyms are treated as in the International Rules—they must be replaced. And secondary homonyms are considered to be such only as long as the two names remain in the same genus. In Fig. 2 we find the top two rows representing the primary homonyms under this definition. A, B, C, D, F, and H are primary, since the later name was already preoccupied by an older combination with *X-us*. But E, which is secondary, must also be replaced, since the names are both in current use in *X-us*. This would appear in the stability tabulation, thus:

Method	*Change*	*Keep*
I. International Rules	8	0
II. Pri-Sec (original genus)	5	3
III. Pri-Sec (validity when proposed)	7	1

(IIIa) A variant of the third procedure might be required by those persons who believe that *temporary* transfer of a name into *X-us* does not preoccupy the name for later use in *X-us*. In this case, A, B, C, D, and E would be primary. This would give results in the stability table of Change 5, Keep 3.

The first of these procedures for separating homonyms into primary and secondary (our second system) is based on two new principles (see Fig. 1): (1) The fact that the identical names were originally proposed in the same genus is held to be of first importance, making the top row primary. In this manner, in Fig. 3, diagram A is set apart from diagram D, although they are identical except for the original assignment of the names, yet we must take the same action in the two cases because there is actual homonymy in each. They must be treated alike even though one is primary and one secondary. In diagrams B and H, which also are identical except for the original genus of the names, we should be required to change a name in B and not in H because B is primary and H is secondary. This time we do not treat them alike, although they differ in exactly the same way. There appears to be no justification for

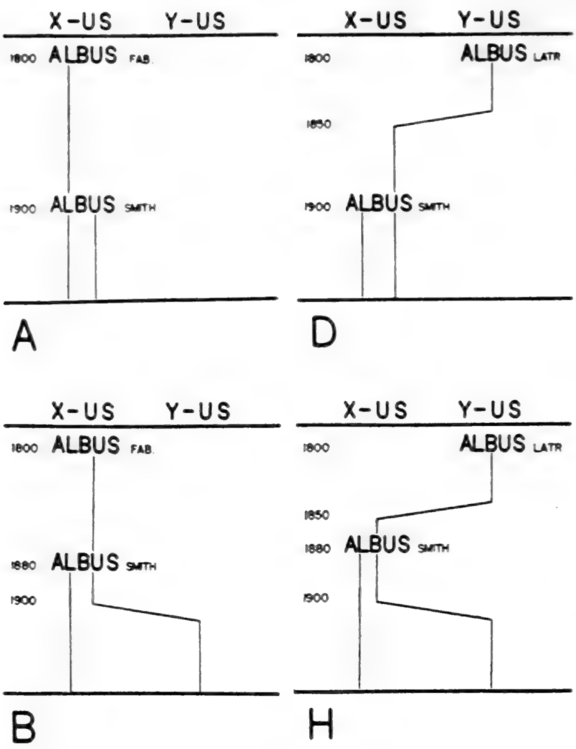

FIG. 3

these distinctions, and there also appears to be no basis for the principle of segregating homonyms on the basis of their original assignment. (2) A secondary homonym must be replaced only if the older name is still in the same genus at the time the homonym is discovered. There can be no question that the younger name in diagram D must be replaced, because there is active homonymy at the present time, but if in diagram H it is not necessary to rename the younger name, why must we do so in diagram B? Merely because of the accident of the original generic assignment of the older name? There appears to be no justification for the use of this principle either.

The second procedure for separating homonyms into primary and secondary uses another new principle (see Fig. 4). It places first importance upon the fact that Smith in 1850 (in E) was correct in believing that the name *albus* had never been used before in the genus *X-us*, whereas in D he failed in 1900 to recognize the older name. D is therefore called primary and E secondary. But in these cases if the older name had been later removed from *X-us* (H and G, in which H is called primary and G secondary) we would be required under this third procedure to replace the newer name in H (because it was a primary homonym) and would not be required to replace it in G (where it is secondary). Again we find that D (primary) and E (secondary) must be treated alike, whereas H (primary) and G (secondary) must be treated differently. There appears to be no reason for such a distinction.

In summarizing these last two procedures, it is apparent that there has appeared the new principle that a name may not be replaced unless the older name is still in the same genus when the homonymy is discovered, as in D and E of Fig. 4. But this principle is applied only to the class of secondary homonyms as variously defined. It would require a change in D and in E, and it would require a change in H but not G. There does not seem to be any reason why all types of homonyms should not be treated in this way. In other words, if there is no real justification for the distinction

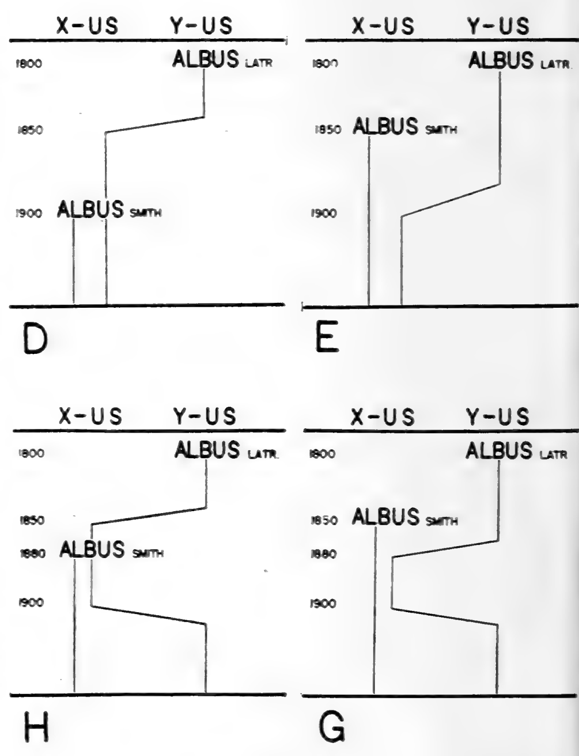

FIG. 4

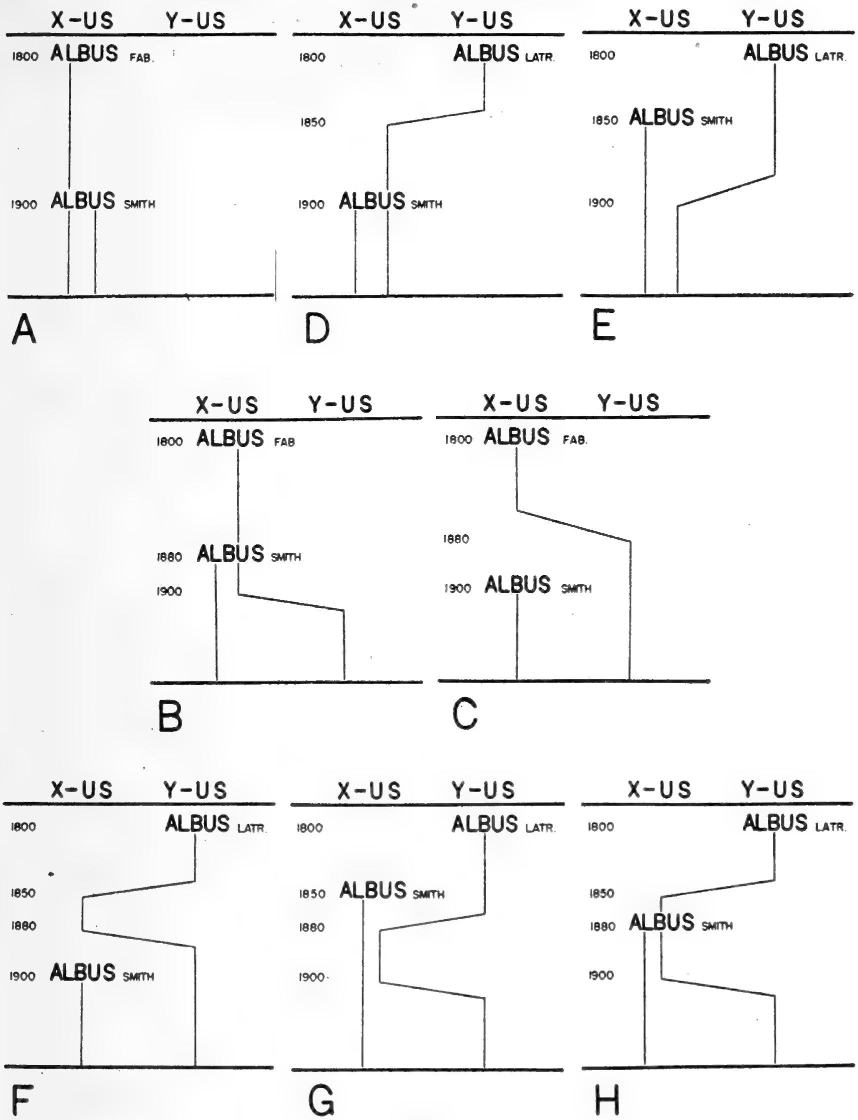

FIG. 5

between primary and secondary, why not judge both types on the same ground?

(IV) Now if we apply this new plan uniformly to all types of homonyms, we need new terms for the ones that are to be replaced and those that are not, to avoid confusion with primary and secondary. We are now interested, in the first place, in the situation as we find it at the time of discovery of the homonymy. (This time is represented by the heavy line across the bottom of each diagram.) The question to be asked is, Is there concurrent use of two names of identical spelling?

In Fig. 5, in A, D, and E two identical names are in use in the genus *X-us* at the present time—they occur together and are therefore *coincident* homonyms. In B, C, F, G, and H the names are not now in the same genus and are therefore homonyms only in an historical sense—only because of their antecedents. We may therefore term them antecedent homonyms.[3]

[3] Other terms may be thought more readily understood in these uses, such as *concurrent* and *historical* or *present* and *past*, but the need for any such terms would be eliminated in a new rule by calling only the first group "homonyms," eliminating the need for any term for the second group.

By replacing only the coincident homonyms, we obtain a rating on the stability tabulation thus:

Method	*Change*	*Keep*
I. International Rules	8	0
II. Pri-Sec (original genus)	5	3
III. Pri-Sec (validity when proposed)	7	1
IIIa.	5	3
IV. Coincident-Antecedent	3	5

I should point out here that in this table a very false impression can be made. These figures are the number of *types* of homonyms that require change. One of these types might be much more common than another, completely overshadowing it in importance. But it appears that in number IV, changes are required only in cases which would have had to be changed under all of the other systems as well (A, D, E in Fig. 5), and the remaining cases are an improvement in stability over the other procedures.

A summary of this distinction between coincident and antecedent homonyms can be made by defining them and the treatment of them. *Any name that is discovered to be of the same spelling as an older name currently assigned to the same genus is a COINCIDENT JUNIOR HOMONYM* and is to be replaced. *Any name that is discovered to be of the same spelling as an older name that was at one time in the same genus but is not now so assigned is an ANTECEDENT JUNIOR HOMONYM* and is not to be replaced.

Obviously, an antecedent homonym can become coincident, as would be the case in diagram C if after 1900 the older name was brought back into *X-us*. It is the actual state of affairs at the time of discovery of the homonymy that determines the type of homonymy and the action to be taken.

In some discussions of primary and secondary homonymy there has been proposed another new principle, which is a radical departure from the International Rules in that it requires the revival of a name previously suppressed as a homonym.

In Fig. 6, which represents a case of secondary homonymy in procedure II, *X-us albus* Smith, 1900, required replacing, even though it was a secondary homonym. It was renamed in 1910 by Jones as *X-us novus*. This is an action that would have been necessary under any of the four procedures we have examined. Then in 1920 *albus* of Latreille, the older name, was removed by Brown from *X-us;* the new procedure would then require that *X-us albus* Smith 1900 be reinstated with *novus* Jones as a synonym.

This appears to be completely contrary to the primary aim of the Rules, which is stability in nomenclature, since it produces an extra name change that is not absolutely necessary. If it stopped here, it would be fairly reasonable, but there is nothing to prevent some other worker from claiming (in 1925 for example) that *albus* of Latreille *was* correctly transferred to *X-us*, and therefore *novus* must be used for *albus* Smith once again. And in 1926 Brown reiterates *his* belief that *albus* Latreille does not belong in *X-us*, and therefore *novus* is only a synonym of *X-us albus* Smith.

It is more than possible that such a controversy should continue for years, since there are many cases in which two authors

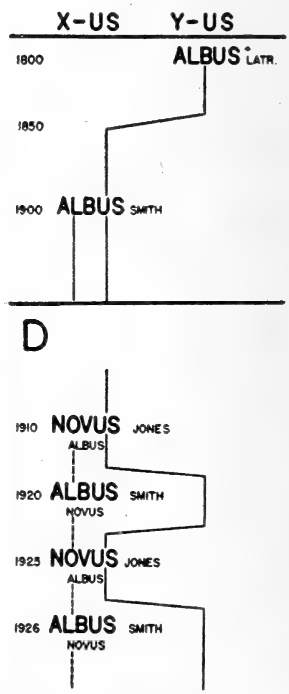

FIG. 6

have consistently used different generic assignments for a given species.

Again, when two workers disagree on the correct generic assignment of a species, as has occurred many times over long periods of years, the first worker, calling the genus *X-us*, finds that *X-us albus* is a secondary homonym, as in D, requiring a new name; whereas simultaneously and equally correctly the second worker, who believes the genus should be called *Z-us*, finds that the name *Z-us albus* is not preoccupied at 1900 and is therefore the correct name for the species. On the basis of their beliefs concerning the generic name, both are correct in their use of the specific names, so that we have two apparently correct names in use for one species.

The possibility of this result from a difference of opinion on generic assignment of another species, or of the correct name for a genus, can not occur under our present Rules. In procedure II as generally stated it can occur in five of the examples. In procedure III it can occur in two of the examples. If the conclusions of this discussion are made part of procedure IV, such a situation could not arise in any case.

The only point that I have seen raised against this principle of accepting a valid renaming in spite of later actions is that malicious transfer could provide the means for some one to rename any species desired, on a small or large scale. I have not found any one who knows of such a case of malicious misappropriation of a rule, and I consider it at best as a possibility of importance insufficient to warrant action designed to prevent it. If a case should occur, the International Commission has ample authority to take action against the offender, without adding to the complexity of our nomenclatural system.

There appears to be no other reasonable course than to accept the valid renaming of a homonym as final. There are other cases in which we find that strict priority gives less stability to names than a carefully controlled departure from priority. And this appears to be an opportunity to prevent the possible (or rather certain) confusion of having two valid trivial names in current use for one species, merely through a difference of opinion concerning the status of some other species which happens to have an identical name.

PROCEEDINGS OF THE ACADEMY

50th ANNUAL MEETING

The 50th annual meeting, concurrently with the 353d meeting of the Academy, held in the Auditorium of the Cosmos Club, January 15, 1948, was called to order at 8:15 p.m. by the President, Waldo L. Schmitt, with 55 persons in attendance.

The minutes of the 49th annual meeting were approved as published in the Journal **37**: 436–444. 1947.

The reports of several officers and of the Committees of Auditors and Tellers were read and accepted. These reports are recorded at the end of the minutes.

After the acceptance of the report of the Committee of Tellers, the President declared the following duly elected to the given offices:

Frederick D. Rossini, *President,*
C. Lewis Gazin, *Secretary,*
Howard S. Rappleye, *Treasurer,*
Francis M. Defandorf and William N. Fenton, *Board of Managers to January 1951.*

The Secretary presented for the Affiliated Societies their nominations for Vice-Presidents of the Academy as follows:

Philosophical Society of Washington—Walter Ramberg
Anthropological Society of Washington—William N. Fenton
Biological Society of Washington—John W. Aldrich
Chemical Society of Washington—Charles E. White
Entomological Society of Washington—Carl F. W. Muesebeck
National Geographic Society—Alexander Wetmore
Geological Society of Washington—William W. Rubey
Medical Society of the District of Columbia—Frederick O. Coe
Columbia Historical Society—Gilbert Grosvenor
Botanical Society of Washington—Ronald Bamford
Washington Section of the Society of American Foresters—William A. Dayton

Washington Society of Engineers—CLIFFORD A. BETTS
Washington Section of the American Institute of Electrical Engineers—FRANCIS B. SILSBEE
Washington Section of the American Society of Mechanical Engineers—MARTIN A. MASON
Helminthological Society of Washington—AUREL O. FOSTER
Washington Branch of the Society of American Bacteriologists—LORE A. ROGERS
Washington Post of the Society of American Military Engineers—CLEMENT L. GARNER
Washington Section of the Institute of Radio Engineers—HERBERT GROVE DORSEY
Washington Section of the American Society of Civil Engineers—OWEN B. FRENCH

The Secretary was instructed by the members present to cast a unanimous ballot for these nominees.

The President announced the recipients of the Academy's Awards for Scientific Achievement for 1947 as follows:

In the Biological Sciences, no award made.

In the Engineering Sciences, HARRY W. WELLS, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in recognition of his distinguished upper-air research and organization of a world-wide network of ionospheric stations.

In the Physical Sciences, ROBERT D. HUNTOON, of the National Bureau of Standards, in recognition of his distinguished service in the advancement of electronics and its applications to other sciences and to modern ordnance.

The reports of three special committees were presented as a part of the program as follows: *The Journal*, by the Chairman of the Committee, RAYMOND J. SEEGER; *National Science Legislation*, by the Chairman of the Committee, A. T. MCPHERSON; *A Junior Academy of Sciences*, by the Vice-Chairman of the Committee, EGBERT H. WALKER.

The retiring President, WALDO L. SCHMITT, presented his address, *The Academy in Retrospect and Prospect*, then appointed Past Presidents EUGENE C. CRITTENDEN and OSCAR E. MEINZER to escort the incoming President, FREDERICK D. ROSSINI, to the chair. Dr. Rossini adjourned the meeting at 10:20 P.M.

REPORT OF THE SECRETARY

During the Academy year, January 16, 1947, to January 15, 1948, one person was elected to honorary membership and 45 persons were elected to regular membership, including 42 resident and 3 nonresident. Of these, 26 resident and 2 nonresident qualified for membership. Ten resident members, elected to membership January 12, 1948, were notified on January 13, but insufficient time has elapsed for their reply. Sixteen resident members and 4 nonresident members elected to membership in the preceding Academy year qualified during the present Academy year just ending. The new members were distributed among the various sciences as follows: 9 in botany, 8 in physics, 5 each in zoology and entomology, 4 each in chemistry and engineering, 2 each in paleontology, geology, anthropology, and plant pathology, and 1 each in biology, bacteriology, genetics, physiology, and ceramics.

Twelve resident and 3 nonresident members, having retired from the gainful practice of their professions, were placed on the retired list of members to enjoy all the privileges of active membership without further payment of dues.

The deaths of the following members were reported to the Secretary:

CHARLES S. BUTLER, Bristol, Tenn., on October 7, 1944.
GEORGES PERRIER, Paris, France, on February 16, 1946.
EDWARD A. GOLDMAN, Washington, D. C., on September 2, 1946.
Sir JAMES HARWOOD JEANS, Dorking, Surrey, England, on September 16, 1946.
WILLIS L. JEPSON, Berkeley, Calif., on November 7, 1946.
HENRY G. AVERS, Washington, D. C., on January 19, 1947.
HOWARD S. ROBERTS, 2d, Washington, D. C., on January 30, 1947.
CHARLES A. BROWNE, Washington, D. C., on February 3, 1947.
W. P. HAY, Bradenton, Fla., on May 26, 1947.
HARDEE CHAMBLISS, Washington, D. C., on June 1, 1947.
RUDOLF W. GLASER, Princeton, N. J., on September 4, 1947.
ROBERT H. LOMBARD, Worcester, Mass., on October 11, 1947.
DWIGHT W. WINDENBURG, Washington, D. C., on November 14, 1947.

Sir JAMES HARWOOD JEANS and General GEORGES PERRIER were honorary members.

On January 15, 1947, the status of membership was as follows:

	Regular	*Retired*	*Honorary*	*Patron*	*Total*
Resident	457	52	2	0	511
Nonresident	161	26	15	0	202
Total	618	78	17	0	713

The net changes in membership during the past year are as follows:

	Regular	*Retired*	*Honorary*	*Patron*	*Total*
Resident	+ 8	+12	0	0	20
Nonresident	+ 9	− 2	−1	0	+ 6
Total	+17	+10	−1	0	+26

During the Academy year 1947 the Board of Managers held 9 meetings, with an average attendance of 18 persons. The following important matters were considered by the Board:

1. *Observance of the 50th Anniversary of the Academy.*—The President appointed a committee to look into the various ways in which the 50th Anniversary of the Academy might be observed and make recommendations to assist the incoming 1948 Board in its selection and carrying out of the observance. It was anticipated that this committee might render timely services inasmuch as the anniversary date, February 18, 1948, falls such a short time after the induction of the new Board of Managers.

2. *Preparation of an Illustrated Anniversary Edition of the "Red Book" or Directory.*—The Board of Managers authorized the publication of an Anniversary Edition of the Red Book, which is to include photographs of members of the Academy together with as complete a list as possible of the membership of the various scientific societies affiliated with the Academy, and to include the constitutions, bylaws and current lists of officers of the Academy and affiliated societies. The Board authorized the expenditure of $3,000 for the publication of the directory, with a leeway of $600 to cover unexpected charges, such as proofreading, etc.

3. *Consideration of a Monograph.*—A monograph on *The parasitic birds of Africa*, by Herbert Friedmann, was presented to the Board of Managers and recommended for publication by the chairman of the Monograph Committee. Estimates for the cost of publication were secured and the Board referred the manuscript to the Board of Editors for review and recommendation.

During the Academy year, seven meetings of the Academy were held as follows:

On February 20, 1947, HUGH L. DRYDEN, as retiring President, offered an address entitled *Exploring the fundamentals of aerodynamics.* Owing to unusually inclement weather the paper was read by title only.

On March 20, 1947, the 1946 Academy Awards for Scientific Achievement were presented to WALDO R. WEDEL, U. S. National Museum, for work in the biological sciences; to MARTIN A. MASON, Beach Erosion Board, for work in the engineering sciences; and GEORGE W. IRVING, Jr., Bureau of Agricultural and Industrial Chemistry, for work in the physical sciences.

On April 17, 1947, His Excellency, Mr. HERMAN ERIKSSON, Minister from Sweden, contributed a few remarks on Alfred Nobel and the Nobel prizes, introducing P. W. BRIDGMAN, of Harvard University, who addressed the Academy on *High pressures and their effects.*

On May 15, 1947, JAMES B. SUMNER, Cornell University, addressed the Academy on *The chemical nature of enzymes.*

On October 16, 1947, EDWARD A. DOISY, St. Louis University School of Medicine, addressed the Academy on *Vitamin K.*

On November 20, 1947, I. I. RABI, Columbia University, addressed the Academy on *The hyperfine structure of the hydrogens and other atoms.*

On January 15, 1948, the meeting of the Academy was devoted to the business of the 50th Annual Meeting and included the address of the retiring President, WALDO L. SCHMITT, entitled *The Academy in retrospect and prospect.*

The meetings were all held in the Assembly Hall of the Cosmos Club.

C. L. GAZIN, *Secretary*

REPORT OF THE TREASURER

Your Treasurer submits the following report concerning the finances of the Washington Academy of Sciences for the year ended December 31, 1947:

RECEIPTS

Dues, 1945	$ 30.00	
1946	75.00	
1947	3,167.00	
1948	70.00	$ 3,342.00

JOURNAL:		
Subscriptions, 1944	$ 6.00	
1945	6.00	
1946	6.00	
1947	735.09	
1948	557.84	
1949	3.38	1,314.31
Reprints, 1946	$ 515.41	
1947	672.73	1,188.14
Sales, 1947		178.07
Interest & Dividends		1,319.11
Directory		0.25
Cash received in connection with the transfer from the 6 percent to the 3.6 percent pref. stock of the Potomac Electric Power Co.		58.00
Payment of balance of principal on the Chicago Railways Bond		750.00
Received from Amer. Assoc. for Adv. of Sci.		479.00
Photostats and postage		2.32
Overpayment of dues		1.00
Total receipts, 1947		$ 8,632.20
Cash balance, Jan. 1, 1947		4,784.25
Total to be accounted for		$13,416.45

DISBURSEMENTS

	1946	*1947*	*Total*
Secretary's Office	$ 82.80	$ 224.95	$ 307.75
Treasurer's Office	21.30	236.78	258.08
Subscr. Mgr. & Custodian		48.36	48.36
Meetings Committee	40.25	327.10	367.35
JOURNAL:			
Printing & Mailing	333.83	3,451.27	3,785.10
Illustrations	50.90	516.44	567.34
Reprints	108.59	399.88	508.47
Office			
Ed. Asst.	20.00	270.00	290.00
Misc., postage, etc.	5.34	33.08	38.42
2—$1,000 Series G bonds		2,000.00	2,000.00
Grants in aid		479.00	479.00
1948 Red Book		292.00	292.00
Set of JOURNALS		100.00	100.00
Share in projector for Cosmos Club		27.85	27.85
Photostats		2.23	2.23
Refund, overpayment of dues		1.00	1.00
Totals	$663.01	$8,409.94	$ 9,072.95
Cash book balance, Dec. 31, 1947			4,343.50
Total accounted for			$13,416.45

RECONCILIATION OF BANK BALANCE

Balance as per cash book, Dec. 31, 1947			$ 4,343.50
Balance as per Amer. Sec. & Trust Co. Statement of Dec. 12, 1947		$4,972.67	
Receipts deposited since Dec. 12, 1947		397.69	
Total		$5,370.36	
Checks outstanding, as of Dec. 31, 1947			
No. 1018	$ 5.41		
1140	5.00		
1201	25.73		
1202	518.36		
1203	292.00		
1204	168.55		
1205	10.81		
1206	1.00	1,026.86	$ 4,343.50

INVESTMENTS

Washington Sanitary Improvement Co.		
Certificate No. 434—100 shares at $10.00	$1,000.00	
Certificate No. 435—100 shares at $10.00	1,000.00	
Certificate No. 527— 8 shares at $10.00	80.00	
Certificate No. 539— 1 share at $10.00	10.00	
Certificate No. 582—200 shares at $10.00	2,000.00	$ 4,090.00
Potomac Electric Power Co.		
Certificate No. TAO 1977—40 shares 3.6 percent pref. at $50.00		2,000.00
City of New York—3 percent (Transit Unification) Due—June 1, 1980		
Certificate No. D 20186	$ 500.00	
Certificate No. C 71038	100.00	
Certificate No. C 71039	100.00	
Certificate No. C 71040	100.00	800.00
First Federal Savings & Loan Ass'n.		
Investment account book		5,000.00
Northwestern Fed. Savings & Loan Ass'n.		
Certificate No. 1380	$4,500.00	
Certificate No. 1441	500.00	5,000.00
United States Government		
Series G Bonds—No. M 332990 G	$1,000.00	
M 332991 G	1,000.00	
M 332992 G	1,000.00	
M 332993 G	1,000.00	
M 1808741 G	1,000.00	
M 2226088 G	1,000.00	
M 2982748 G	1,000.00	
M 4126041 G	1,000.00	
M 5141346 G	1,000.00	
M 5141347 G	1,000.00	10,000.00
American Security and Trust Co.		
Savings Account		46.87
Total		$26,936.87
Cash balance 12/31/47		4,343.50
Total		$31,280.37
Total as of Dec. 31, 1946	$30,718.62	
Total as of Dec. 31, 1947	31,280.37	
	$ 561.75	

At the close of business on December 31, 1947, there were 50 members of the Academy who were in arrears, as follows:

	No. of members	*In arrears for*
	25	1 year
	11	2 years
	5	3 years
	2	4 years
	6	5 years
	1	6 years
Total	50	

Probably at least half of these will regain the status of "member in good standing" eventually. However, the above tabulation shows plainly that a "house cleaning" is in order, and it is hoped that this work can be attended to early in 1948.

Howard S. Rappleye, *Treasurer.*

REPORT OF AUDITING COMMITTEE

The accounts of the Treasurer of the Washington Academy of Sciences for the year 1947 were examined by your auditing committee on January 12, 1948.

The Treasurer's report was checked and found to be in agreement with the records. All disbursements had been authorized and were found to be supported by vouchers and cancelled checks. The securities of the Society were inspected and found to be in agreement with the list given in the report and to have all coupons attached that are not yet due.

Your Committee highly commends the Treasurer of the Academy upon the orderly and businesslike manner in which he has maintained the fiscal records. The Academy continues to be indebted to Mr. Rappleye for his conscientious and efficient performance of the arduous duties of his office.

Frederick D. Rossini, Chairman
Austin H. Clark
Harold E. McComb

REPORT OF THE BOARD OF EDITORS

Volume 37 of the Journal, for the year 1947, contained 448 pages in 12 issues, a gain of 16 pages over Volume 36 of the previous year, in this respect more nearly approximating the ideal of 500 pages recommended by previous editors. There were 59 papers distributed among the various sciences as shown in the table below.

These figures show an even poorer balance between the physical sciences and the biological sciences than the previous year. In 1946 about one-fourth of the pages of the Journal were devoted to physical sciences including geology, whereas in 1947 the papers in the physical sciences used only about one-tenth of the pages of the Journal. The disproportion reflects the production of the biologists and the activity of the freshman editor, Dr. Stone, who has been successful in procuring good papers. In 1947, moreover, the members of the Academy submitted over 50 percent of the papers published, an improvement over 1946 when less than half of the papers were submitted by our own members. A considerably larger number of papers was received than the editors felt merited publication in the Journal. A slight decline in the number of papers published this year is offset by the space given to several papers, of which at least one has been widely noticed in this country and abroad. Anthropology continues to contribute a fair share of papers, and papers from its constituent disciplines may be expected to be a substantial part of the Journal. Owing to the vigilance of Dr. Hoffman, who assumed responsibility for necrology, the number of obituaries procured was double that of 1946.

The Journal and the new Board of Editors face the new year with confidence. Instead of the customary dearth of papers, the supply on hand will carry the Journal through the first quarter of the year. Among the papers on hand and at the printer's are several in the physical sciences which the editors gathered during 1947 or which came to them through the activities of the Meetings Committee.

The Journal faced a financial crisis in September, when the George Banta Publishing Co., through its representative, informed the Senior Editor, Dr. W. N. Fenton, that the costs of printing had increased to the extent that they had found it necessary to submit a new contract which, in effect, would increase the cost of printing the Journal by about 31 percent. Dr. Fenton reported the matter to the Board of Managers, who referred the question to the Executive Committee, who, meeting October 13, 1947, recommended action, which the Board of Managers voted, October 20, to

Sciences	Number of papers, 1947	Number of pages, 1947	Percentage by pages, 1947	Number of pages, 1946	Percentage of pages, 1946
Biological	41	241	53.8	178.8	41.4
Physical	3	37	8.3	78.8	18.2
Anthropological	11	90	20.1	114.0	26.4
Geological	2	12	2.7	24.2	5.6
Other (History of Science)	2	19	4.2	9.5	2.2
Obituaries, Proceedings, etc.	—	45	10.0	23.0	5.3
Index	—	4	0.9	4.0	0.9
Totals	59	448	100.0	432.0	100.0

increase the budget for the JOURNAL by $225 to meet the increase in cost of publication for the remainder of the year, and authorized Dr. FENTON to sign the new contract with the George Banta Publishing Co. for printing the JOURNAL.

The original 1947 budget provided $4,000 for printing and mailing, to which was added $225 (mentioned above), $300 for editorial assistance, and $50 for miscellaneous office supplies and postage, bringing the total to $4,575. To this is to be added the charges to authors, which amounted to $936.38, making a grand total of $5,511.38.

The disbursements for the JOURNAL have been:

Printing and mailing	$3,831.14
Illustrations	532.95
Reprints	473.64
Editorial assistance	295.00
Office, miscellaneous	42.31
Total	$5,175.04

To recapitulate, the total cost of the printing bills was $4,837.73. From this may be subtracted $936.38, the amount charged to authors for reprints, excess illustrations, and excess typesetting charges. Thus the net cost to the Academy of printing the JOURNAL was $3,901.35.

It should be noted that on several items the Editors are well within their appropriation and that, despite the rise in printing costs at the end of the year, they were able to get by without the supplemental appropriation.

The Board of Editors wishes to acknowledge the cooperation of the Board of Managers and the officers of the Academy. The Associate Editors met with the Board of Editors early in the year and worked out a procedure for handling manuscripts in special fields, for reading galley proofs, and for consultation, in all of which the Associate Editors have supported the Board of Editors ably and willingly. Dr. R. E. BLACKWELDER supplied for Dr. STONE during the latter's field work in Alaska, and special thanks are due to Mr. PAUL H. OEHSER, our editorial assistant, for taking over administrative duties during the summer months while Dr. FENTON was away teaching. Mr. OEHSER's very considerable specialized knowledge and his genuine interest in the continual improvement of the JOURNAL far exceed the implication of his title.

The Editors also wish to cite Mr. IRWIN H. WENSINK, Washington representative of the George Banta Publishing Co., for his help in maintaining the continuity and high standard of the JOURNAL and for the courteous way that he conducted negotiations for a new contract for his company. We do not think it entirely flattery when he tells us that the Academy's editorial set-up has come to be a model which his company recommends to other learned bodies.

WILLIAM N. FENTON
JAMES I. HOFFMAN
ALAN STONE

REPORT OF THE CUSTODIAN AND SUBSCRIPTION MANAGER OF PUBLICATIONS

SUBSCRIPTIONS:

Nonmember subscriptions in the United States	131
Nonmember subscriptions in foreign countries	75
Total	206

INVENTORY OF STOCK AS OF DECEMBER 31, 1947:

Reserve Sets of the JOURNAL:	
Bound Volumes 1–29 and unbound Volumes 30–37	1 set
Unbound Volumes 1–37	3 sets
Unbound Volumes 11–37	6 sets
Unbound Volumes 16–37	11 sets
Miscellaneous numbers of the JOURNAL	18,911
Total numbers in the Reserve Sets	8,070
Grand total of back numbers	26,981

The only important change that has taken place during the year 1947 was the resignation of FRANK M. SETZLER as Custodian and Subscription Manager of Publications. Mr. SETZLER was forced to hand in his resignation toward the end of this year because of his leaving the country for an extended field trip. To fill this vacancy, I was appointed at the 411th meeting of the Board of Managers held on October 20, 1747. Mr. SETZLER has admirably filled this position for five years, and during this tenure of office he has organized the operations and records in a most efficient manner, so that when I took over this position I found everything in perfect order and all information readily accessible. I feel that Mr. SETZLER deserves to be highly commended for the excellent way in which he has run this office.

SALES AND EXPENDITURES:

During the year no complete sets were sold, but the sale of individual volumes and numbers

has continued, 24 volumes and 115 numbers having been sold. One complete set (Vol. 1–36) was purchased from one of the members of the Academy.

Income from Sales	
Miscellaneous numbers	$178.07
Expenditures	
Set of JOURNAL Vol. 1–36	$100.00*
Postage and office expenses	48.36
1947 Budgetary allotment	$ 50.00†
Enexpenditures for 1947	48.36
Unexpended balance	$ 1.64

* Deducted from special fund earmarked for purchase of volumes and numbers needed to form complete reserve sets.

† This does not include the additional $50 that was added to the budget allotment by vote of the Executive Committee for the purpose of carrying out a campaign to increase the present subscription list. This money was not expended in 1947.

HARALD A. REHDER, *Custodian and Subscription Manager of Publications*

REPORT OF THE COMMITTEE OF TELLERS

A total of 325 envelopes were delivered to the Secretary. The count of valid ballots showed the following officers were elected:

President, FREDERICK D. ROSSINI
Secretary, C. LEWIS GAZIN
Treasurer, HOWARD S. RAPPLEYE
Board of Managers to January 1951, FRANCIS M. DEFANDORF and WILLIAM N. FENTON

ANNA E. JENKINS, *Chairman*
MIRIAM L. BOMHARD
REGINA FLANNERY

REPORT OF SPECIAL COMMITTEE ON LEGISLATION (ABSTRACT)

The Committee on Legislation, composed of J. E. GRAF, W. W. RUBEY, and A. T. MCPHERSON, reported on recent and pending legislation in three phases of Government activity, each of especial interest and importance to science. Unusual possibilities for the advancement of science were seen in the international exchange of scholars and information provided by the Fulbright Foreign Scholarship Act (Public Law 584, 79th Congress) and by the proposed Information and Educational Exchange Act of 1948 (HR 3342, January 7, 1948). Funds for the program under the former act are in foreign currencies derived from the sale of surplus war property abroad. The latter bill which was expected to be passed at an early date contains provision for the dollars needed to send American scholars abroad and will extend the international exchange of scholars to countries in which there was no surplus property.

The second phase of legislative action reported on was that concerned with the future of the synthetic rubber industry. The Committee felt that the most important consideration for future national security regarding rubber lay in establishing an adequate research and development program, entirely apart from any production program. The cost of such a program would be less even than the cost of maintaining the unused plants in standby condition.

The third subject dealt with by the Committee was that of the National Science Foundation. At the time of the report, it was thought that a compromise bill acceptable to both the Congress and the Administration would be introduced soon.

The recent report of the President's Scientific Research Board was reviewed and was compared with a similar study made by Rosa after World War I.* The fact that many of the recommendations regarding the scientific program of the Government made in the Rosa report are similar to those in the current report was cited by the Committee in support of their recommendation that the Academy give serious and sustained attention to legislation relating to science.

A. T. MCPHERSON, *Chairman*

REPORT OF THE SPECIAL COMMITTEE ON A JUNIOR WASHINGTON ACADEMY OF SCIENCES

DR. WALDO L. SCHMITT, President of the Washington Academy of Sciences in 1947, appointed a committee on junior academies of science consisting of Austin H. Clark, Chairman, E. H. Walker, Vice Chairman, and Frank Thone, and requested it to study the subject and make recommendations to the Washington Academy of Sciences. The following is the report of the vice chairman based upon the results of the study as given in his talk at the 50th

* *Expenditures and revenues of the Federal Government*, by EDWARD B. ROSA. Publication No. 1518. Reprinted from "Taxation and Public Expenditures," Vol. 95 of the Annals of the American Academy of Political and Social Science, Philadelphia, May 1921.

annual meeting of the Washington Academy on January 15, 1948.

The growing interest in the early recognition and encouragement of potential scientists has found expression in the development of organizations working with and for these young scientists. Their activities are centered largely on the approximately 15,000 science clubs in the secondary schools throughout the country. Assisting in the coordinating of these clubs is Science Clubs of America, administered by Science Service, Inc., Washington, D. C. An important activity of this coordinating organization is the conducting of the annual Science Talent Search for the Westinghouse Science Scholarships. Scholarships totaling $11,000 are distributed among the 40 winners on the basis of a nation-wide examination. In 11 states additional awards are granted to local winners in this same examination, this usually under the auspices of the state junior or senior academies of science.

Junior academies of science exist in more than 30 states. The first one was formed in Illinois in 1919. These organizations provide to the young scientists and their sponsors, mostly organized into school science clubs, (1) valuable training through cooperative endeavors; (2) association with other young scientists and with adult scientists; (3) incentives to the students through exhibits, fairs, and congresses, to engage in creative activities; (4) incentives and assistance to the adult sponsors; (5) insight into senior scientific organizations and their activities; and (6) opportunities to take an active part in adult scientific projects.

Membership in these junior academies usually consists of the science clubs as chapters and their members as individuals. They are variously financed, the funds coming from dues paid by the chapters or by the members, or both, and subsidies by senior academies, teacher organizations, sponsors, friends, commercial organizations, etc. Sums run from about $20 to $400 annually. Additional services and facilities are often provided by associated and sponsoring organizations.

The Junior academies of science are usually governed by committees of the senior academies and of the school sponsors of the clubs. They function best where there is an experienced and active adult leader on both committees or at least actively supported by them.

These junior academies, besides assisting in the conduct of the science clubs' activities, provide stimulating and coordinating publications, sectional meetings, an annual state congress, usually in connection with the annual state academy meeting, with exhibits, fairs, trips, talks, etc., and awards of various kinds. They often enlist the aid of juniors in various senior scientific projects where such is appropriate.

The organization of a Junior Washington Academy of Science is favored by local individuals and organizations engaged in junior scientific work. The head of the science work in the public schools and the teacher-sponsors of the science clubs believe it would be a spur to their efforts and could provide valuable facilities they are otherwise unable to obtain. Science Clubs of America would be glad for such an Academy to take over its responsibilities in the annual science fair, an activity which it has previously assumed in the absence of other suitable organizations to do so. It would be glad to assist in the selection of the best science talent in this area for awards in addition to the national Westinghouse Science Scholarships.

This committee's investigation of the local organizations and individuals who might be interested in this project is incomplete. More work should be done in this field before a final plan of organization is prepared. There should be careful investigation of the activities of the Virginia Junior Academy of Science, centered in Charlottesville, in order to coordinate the considered activities of a Junior Washington Academy of Sciences with those of this nearby organization working within the greater Washington area. We have had a preliminary meeting with officers of the Maryland Academy of Sciences in Baltimore and find that our activities would supplement theirs in the adjacent portion of Maryland, with which we might be concerned, and that cooperation with that organization would be highly desirable and welcomed. Their junior academy is temporarily suspended for lack of a director, but much junior work is being carried on along with their program of interpretation of science. The different emphases and perspectives of the Maryland and of the Washington Academies of Science would find common ground through this proposed Junior Washington Academy of Sciences.

We, therefore, recommend that the Board in control of the Washington Academy of Sciences continue this committee with new or augmented personnel and instruct it to report at the April meeting of the Academy definite and detailed plans for organizing a Junior Washington Academy of Sciences with proposals for implementing this plan.

EGBERT H. WALKER, *Vice Chairman*

REPORT OF SPECIAL COMMITTEE TO CONSIDER VARIOUS MATTERS PERTAINING TO THE JOURNAL AND ITS IMPROVEMENT

The report of this committee was included in the published Proceedings of the Academy, 414th Meeting of the Board of Managers: This JOURNAL **38** (2): 79–80. Feb. 15, 1948.

Submitted by C. LEWIS GAZIN, *Secretary*

417TH MEETING OF BOARD OF MANAGERS

The 417th meeting of the Board of Managers, held in the Cosmos Club, April 12, 1948, was called to order at 8:05 P.M. by the President, Dr. F. D. ROSSINI. Others present were: H. S. RAPPLEYE, N. R. SMITH, H. A. REHDER, W. W. DIEHL, W. RAMBERG, T. D. STEWART, C. E. WHITE, A. WETMORE, W. A. DAYTON, C. A. BETTS, M. A. MASON, L. A. ROGERS, C. L. GAZIN, and, by invitation, H. E. McCOMB, R. J. SEEGER, A. STONE, J. E. GRAF, and F. H. H. ROBERTS, JR.

The following appointments were announced by the President: *Committee on the Index of the Journal:* W. N. FENTON, Chairman, J. I. HOFFMAN, M. C. MERRILL, H. A. REHDER, PAUL H. OEHSER (consultant). *Committee on Functions and Policies of the Academy:* E. C. CRITTENDEN, Chairman, A. H. CLARK, W. A. DAYTON, M. A. MASON, L. W. PARR, F. B. SILSBEE.

The Chairman of the Meetings Committee announced that Prof. PHILIPP FRANK, of Harvard University, would speak at the April meeting of the Academy.

The Chairman of the Special Committee to consider certain revisions of the Bylaws of the Academy and Standing Rules of the Board of Managers, Dr. WALTER RAMBERG, read the following report:

The Committee has considered means of revising the Standing Rules of the Board of Managers in order to provide greater continuity in the Standing Committees of the Board. The Committee recommends the following revisions for this purpose:

Standing Rules

Section 3, third sentence, replace by: "The Committee on Membership, Meetings, Grants-in-Aid for Research, and each of the Subcommittees of the Committee on Awards for Scientific Achievement shall include, if possible, at least two members reappointed from the preceding year. The Committee on Monographs shall have six members, each appointed for 3 years at the rate of two each year. At least three members of the Committee on Monographs shall be past editors of the JOURNAL, if possible."

In addition the Committee recommends the following revision in the Standing Rules in order to describe more accurately the duties of the Committee on Awards for Scientific Achievement:

New Section 8, second sentence, replace by: "A candidate must be a member of the Washington Academy of Sciences or a resident member of one of the affiliated societies, and shall not have passed the 40th anniversary of the date of his birth by the end of the calendar year for which the award is made; recommendations by the Committee must reach the Board of Managers not later than the meeting preceding the Annual Meeting of the Academy in January."

The Chairman of the Committee on Science Legislation, JOHN E. GRAF, reported that Senate Bill 526 had been vetoed by President Truman but that Senator Smith of New Jersey was sponsoring S3285, introduced March 25, which would overcome some of the objections raised to the previous bill.

The president announced that the results of the study to be made by the Special Committee appointed to consider the policy and functions of the Academy were to be available by the end of the calendar year and to be published in the JOURNAL as a matter of permanent record and in order to bring them to the attention of the membership of the Academy.

Changes in the Standing Rules of the Board of Managers introduced at the 416th meeting were approved as follows:

Section 2

After c. iv., insert:

"v. Committee on Awards for Scientific Achievement."

"vi. Committee on Grants-in-aid for Research."

Section 3

Replace first sentence by: "There shall be six STANDING COMMITTEES, as follows: Executive

Committee, Committee on Meetings, Committee on Membership, Committee on Monographs, Committee on Awards for Scientific Achievement, Committee on Grants-in-Aid for Research."

Section 4, first sentence:

In place of "or acting President," insert "President-Elect" (providing the Academy approves of the new office of President-Elect).

Following Section 6, insert:

7. The COMMITTEE ON MONOGRAPHS shall receive for review and recommendation regarding publication such monographs as may be submitted to the Academy, preference being given to members of the Academy.

8. It shall be the duty of the COMMITTEE ON AWARDS FOR SCIENTIFIC ACHIEVEMENT of recommending one candidate each for the Biological Sciences, the Engineering Sciences, and the Physical Sciences. A candidate shall not have passed the 40th anniversary of the date of his birth by the end of the calendar year for which the Award is made; recommendations by the Committee must reach the Board of Managers not later than the meeting immediately preceding the annual meeting of the Academy in January. Each recommendation to the Board must be accompanied by a written supporting statement giving the necessary information concerning the candidate, together with a citation covering not over 80 spaces, as "in recognition of his distinguished service in ——(80 spaces)——."

9. The COMMITTEE ON GRANTS-IN-AID FOR RESEARCH shall review applications for grants-in-aid from such funds as may be at the disposal of the Board of Managers for this purpose.

Renumber:

present Section 7 as new Section 10
present Section 8 as new Section 11
present Section 9 as new Section 12
present Section 10 as new Section 13
present Section 11 as new Section 14
present Section 12 as new Section 15.

The meeting was adjourned at 9:35 P.M.

C. LEWIS GAZIN, *Secretary.*

Obituary

GEORGE ROGERS MANSFIELD, retired geologist of the U. S. Geological Survey, member of the Geological Society of Washington, and its 39th President in 1930, died at the home of one of his daughters, Mrs. John W. Carroll, at Swarthmore, Pa., on Sunday, July 11, 1947. He was born August 30, 1875, in Gloucester, Mass. At Amherst College he received the B.S. degree and membership in Phi Beta Kappa in 1897, and the M.A. degree in 1901. From 1897 to 1903 he was science teacher at Central High School in Cleveland, Ohio. At Harvard University he received the Ph.D. degree in 1906 and was instructor in geology from 1906 to 1909. At Northwestern University he was assistant professor in geology from 1909 to 1912. He worked during the summers of 1910 to 1912 for the U. S. Geological Survey in Idaho. In 1913 he joined the permanent staff as geologist and was placed in charge of phosphate investigations, which he carried on for many years. In 1922 he was made chief of the Section of Nonmetalliferous Deposits, in 1921 editor of geologic maps, and in 1927 chief of the Section of Areal and Nonmetalliferous Geology. He retired in 1943.

Dr. Mansfield's contributions to geology over a period of 36 years (1906–42), include 109 titles, of which Professional Paper 152: *Geography, geology, and mineral resources of a part of southeastern Idaho*, published in 1927, may be cited as an example of his outstanding competence in investigation, description, discussion and solution of the areal, physiographic, stratigraphic, structural, and economic problems encountered in the detailed study of an area (in this case of some 2,200 square miles). Other publications of the Survey of which he was either author or joint author described the phosphates of Florida, the greensands of New Jersey, the nitrates of California, Texas, Idaho, and Oregon, and the potash deposits of Texas and New Mexico. His other contributions appeared in many publications, mainly those of the Geological Society of America, American Association of Geographers, the American Journal of Science (of which he was associate editor from 1938 to 1945), the Journal of Geology, Washington Academy of Sciences, Industrial and Engineering Chemistry, Economic Geology, Science, Proceedings of Section E of the American Association for the Advancement of Science.

He was a member of the National Research Council 1925 to 1934 and chairman of the committee on tectonics from 1924 to 1934, a fellow of the Geological Society of America, and a member of the American Institute of Mining

and Metallurgical Engineers, the Society of Economic Geologists, the American Geophysical Union, the Washington Academy of Sciences (vice president 1931), and the Cosmos Club.

He is survived by his wife, Adelaide Clafin Mansfield; three sons, Harvey C. Mansfield, a professor of political science at Ohio State University, Dr. James S. Mansfield, of Cambridge, Mass., and Robert H. Mansfield, of Caracas, Venezuela; two daughters, Mrs. George W. Patterson, of Morton, Pa., and Mrs. John W. Carroll, of Swarthmore, Pa.; and twelve grandchildren.

RALPH W. RICHARDS

Officers of the Washington Academy of Sciences

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) Short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

Manuscripts may be sent to any member of the Board of Editors. It is urgently requested that contributors consult the latest numbers of the JOURNAL and conform their manuscripts to the usage found there as regards arrangement of title, subheads, synonymies, footnotes, tables, bibliography, legends for illustrations, and other matter. Manuscripts should be typewritten, double-spaced, on good paper. Footnotes should be numbered serially in pencil and submitted on a separate sheet. The editors do not assume responsibility for the ideas expressed by the author, nor can they undertake to correct other than obvious minor errors.

Illustrations in excess of the equivalent (in cost) of one full-page halftone are to be paid for by the author.

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JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 38 JULY 15, 1948 No. 7

ARCHEOLOGY.—*Florida archeology and recent ecological changes.*[1] JOHN M. GOGGIN, Peabody Museum of Natural History, Yale University. (Communicated by W. R. WEDEL.)

American archeology in the past few years has turned to several of the natural sciences for aid in dating recent sites and for a fuller understanding of the natural environment in which primitive man played his role. In the Southwest, for example, archeologists have been able to obtain calendric or absolute dates from the study of tree rings (Glock, 1937; Haury, 1935). Pollen analysis, of considerable value in European prehistory, also shows promise of utility in the New World (Sears, 1937). Other methods of dating and interpretation are based upon work done by the geologist and conchologist (Baker, 1937; Richards, 1937).

The best results are now being obtained by cooperative research on the part of both archeologists and natural scientists. Two such studies can be briefly summarized: One in Oregon gave a relative date for archeological material sealed in a cave deposit under volcanic ash. The same ash layer was found in peat deposits. By pollen analysis the history of the peat deposit was worked out, and the relative date of this ash layer was determined, which in turn gave an upper limit relative date for the archeological material in the cave.[2]

Another recent example of a combined project of this type is the Boylston Street fishweir. In the course of a construction excavation in Boston the remains of a fishweir were found many feet below the present surface of the land. The indications are that man lived in the Charles River estuary "when the level of the sea in relation to land, was about fifteen feet eight inches lower than it is at the present time" (Johnson et al., 1942). A more recent joint problem of archeology and botany is the Grassy Island site (Johnson and Raup, 1947).[3]

Approaches like these were originally developed in the Old World where the usual time span involved was much greater.[4] Although American archeologists had been aware of the European results, it was thought until recently that the length of time in which the greatest developments in American cultures took place was too short to have resulted in ecological changes of any importance. It is now realized that while the changes that have taken place in the New World are not so sharp as those in some parts of Europe, such as in Scandinavia, nevertheless they are present and can be detected by more refined analysis.

[1] Data used in this paper were gathered as part of the Yale Caribbean Program directed by Dr. Cornelius Osgood. The 1947 summer's work was done under a fellowship from the Social Science Research Council. Many persons have been very helpful in offering me unpublished data, especially Irving Rouse, Vera M. Masius, and John W. Griffin. Others have generously read and criticized the manuscript. For this special thanks are due Frederick Johnson, R. S. Peabody Foundation, Phillips Academy, Andover, Mass.; Irving Rouse, Department of Anthropology, Yale University; Richard F. Flint, Department of Geology, Yale University; and Martin Burkenroad Newport, North Carolina. Received March 22, 1948.

[2] *Symposium on Early Man in Oregon*: Cressman, 1946; Hansen, 1946; Allison, 1946. Hansen, 1947.

[3] As a point of historical interest it can be noted that E. S. Morse was perhaps one of the first to point out a series of ecological changes in vegetation, species of animals, and erosional factors in a single Maine shell heap (1868; 1925: 430).

[4] A complete summary of the methods and results of archeological and geological dating will be found in Zeuner, 1946.

The twofold problem facing the archeologist can be briefly summarized as follows: The first phase will necessitate the preparation of a detailed ecological history of late Pleistocene and Recent times covering the climate, the composition and changes in flora and fauna, and the changes in land form, especially the coast line. These are factors directly affecting primitive man on a simple subsistence level. The second problem, of special interest to the archeologist, is whether any of these changes can be used for either absolute or comparative dating. A hope for absolute dating possibly lies in the analysis of some constant process such as tree rings or the deposition of sediments like varves or peats, and less likely in sea-level changes. But sea-level changes, as well as ecological changes, do offer hope of comparative correlations with other regions where similar conditions can be observed.

The analysis of climatic fluctuations with the attendant floral and faunal changes also offers much hope for comparative correlations. This should be especially helpful in Florida where a relatively sharp temperate versus tropical physiographic line can now be drawn. Minor climatic changes, only scantily reflected in either more temperate or tropical regions, probably resulted in appreciable movements of the border line in Florida.[5] This meant that abrupt changes often took place in Florida, which necessitated adjustment of the biota to the new conditions.

In the course of recent archeological work in Florida the writer has noticed a number of situations that may offer valuable information if they can be considered in detail by competent specialists. It is the object of this paper to bring these situations to the attention of the respective specialists in the hope that they may be stimulated to follow up some of the problems, or to instill an awareness of the problems in event that similar situations arise in routine biological or geological research. Some of the following situations have been directly observed in the field and others are taken from existing literature. In most cases there is not enough information to formulate concrete conclusions. They must be thought of as interesting leads offering promise with future detailed work.

No attempt has been made to gather similar data from purely natural-history sources or to evaluate the material presented here in terms of other ecological data. To repeat, it is the purpose of this paper to present evidence of ecological changes that can be related to human activity in this region for dating purposes. An explanation of the various archeological cultures referred to in this article will be found in a recent paper (Goggin, 1947). A chronological chart from that paper is reproduced here (Fig. 1).

Changes in sea level.—Careful measurements in recent years have brought forth data on the rise of sea level relative to a stable coast line (Flint, 1947: 426–428). In south Florida this rise has been demonstrated by Davis (1940: 402–405; 1946: 180–181) in his study of the mangrove swamp.

It is of interest therefore to be able to correlate this rise in sea level with sites occupied by man. Numerous midden sites in southern Florida, particularly those on the lower east coast, in the Ten Thousand Islands, and in the Cape Sable region, which are now small islands in the mangroves, were probably on dry land when first occupied. A good example is one located in the present village of Surfside north of Miami Beach. This site consists of a black dirt and shell midden with an adjacent burial mound made of beach sand. The midden site was first occupied in Glades II times, but the burial mound is believed to date from Glades III times (Fig. 1). Previous to the filling operations the site was a small dry, hammock-covered island in the mangrove swamp.

Excavation in the burial mound has revealed the lowermost group of human bones to be completely below low tide level. No mangrove peat underlies the mound. It is

[5] It is probably no accident that the bulk of the comparable data for ecological changes in Eastern United States, mentioned in later sections of this paper, comes from Maine. This too is a physiographic boundary area and climatic variances would make appreciable changes here as in Florida. An area in the middle of a large physiographic region, Virginia for example, would not be affected by variances which would result in pronounced changes in Florida or Maine.

very unlikely that the burials were made under water and then covered with sand; therefore the sea level must have risen since the burials were deposited. This postulation is substantiated by trenches in the midden part of the site, which show that deposit to be resting on clean beach sand, not mangrove peat.

A reconstruction of the history of the site would be as follows: The first occupation here was on the dry inner shore of the beach ridge. Subsequently the rise of sea level inundated the low shoreline and isolated the site, which by that time had been built up enough to be above the rising sea. Thus the site became an island which in time was surrounded by a mangrove swamp.

Changes in ground-water level.—In parts of southern Florida there has been an appreciable demonstrable rise in ground-water level, which is in some places associated with a deposition of sediments.

South Indian Field is a sand midden site in the valley of the St. Johns River near its head, west of Malabar, Brevard County. This little cabbage-palm hammock is a mound composed of sand and refuse about 3 feet higher than the surrounding sawgrass prairie (Rouse, MS.). Previous to modern drainage water normally surrounded the site, and often only the constricted highest portions were above water.

Excavations in the site (Masius, MS.) indicate that the first occupation began here on a level approximately the same as the present surface of the prairie. As refuse accumulated the site was built to its present height. In terms of the archeological picture this site was fairly early, its initial occupation in the Orange Period being about 700 A. D. or earlier (Fig. 1).

An interesting problem is posed here (Rouse, MS.). In the light of recent conditions, the earliest level of the site could not have been a suitable camp site for the Indians, for it was never dry enough. Even

	Lower Mississippi Valley	Gulf Coast			Glades Area (4)	St. Johns	
		Northwest Gulf Coast (1)	Central Gulf Coast (2)	Manatee Region (3)		Melbourne Region (6)	Northern St. Johns Region (7)
1700	Natchez	Fort Walton	Safety Harbor	Safety Harbor	Glades c	St. Johns II	St. Johns II
1600	Plaquemine			?			
1500				Englewood Ceramic Series	Glades b		
1400	Coles Creek	Weeden Island II	Weeden Island II	Weeden Island II	Glades III a		
1300							
1200							
1100	Troyville	Weeden Island I	Weeden Island I	Weeden Island I (?)	Glades II	St. Johns I	St. Johns I
1000							
900	Marksville	Santa Rosa–Swift Creek	Pre-Weeden Island	Pre-Weeden Island	Glades I		
800	Tchefuncte	Deptford				Orange	Tick Island
700		Pre-Deptford (?)					
600							
500	Copell (Non-Ceramic)					Non-Ceramic(?)	Non-Ceramic
400							
300							
200							

Fig. 1.—Archeological areas and periods in Florida. The term "Archaic Horizon," as used in the text, refers to the Orange, Tick Island, and Nonceramic periods.

a short seasonal dry spell or several years of drought would not have given a sufficient period of time for the beginnings of the midden, as the deposit shows no signs of a rapid accumulation which might have enabled its builders to get above the present water level. Therefore, we have to postulate a different initial ecological condition, one in which the prairie was completely dry. Since that time the water table has risen and the surrounding area become a marsh.

As corroborative evidence for the dryness of the locality Rouse (MS.) has noted that the present surface material of the prairie is sand, but until recently there was a thin layer of muck or peat, which has burned off since drainage. There is no muck under the refuse deposit; so such material must have formed since the development of the site. In addition there are traces of a large number of pits which were dug around the site during the early period of occupation. They seem admirable wells, but otherwise their presence is difficult to account for. Under present conditions (that is, before drainage) wells are not needed, but if the prairie was once dry they would have been very necessary.

Several possible theories to account for the apparent history of this locality can be given, but field study is necessary to determine the true cause. A rise in sea level would result in a higher ground-water table, but this could only account for part of the rise. Increased precipitation would certainly be important, and another possible factor would be the damming up of the St. Johns Valley farther down the river, by the development of extensive peat beds.

Archeological sites in the northern Everglades, on the south shore of Lake Okeechobee, are found in conditions indicating considerable rise in ground water level along with sedimentation. The large midden site at Chosen near Belle Glade has a foot of muck over its edges, while the bottom was two feet below the 1934 ground surface (Stirling, 1935: 374; Willey, MS.). A consideration of local muck subsidence probably would increase this depth figure. The midden must have been begun at some period of low water when the Everglades were dry or nearly so, possibly at one of the low water stages indicated by Dachnowski-Stokes (1930).

At South Bay, to the west of Belle Glade, even deeper archeological sites have been reported.[6] These are small midden deposits with animal bones and pottery which lay about three feet below the present surface of the muck. A number of these have been noted in the sides of drainage ditches in this region. All appear to be on the same stratigraphic horizon. The reported two-foot subsidence in this region gives an original depth of five feet for these small sites. Like the Belle Glade site, they could not have been formed under anything similar to the modern predrainage conditions, but must have been begun at a relatively dry period.

Changes in local ecology.—There is some archeological evidence that coastal lagoons such as the Indian River and Halifax River were once much fresher than in recent years.

The Florida Archaic peoples, using fiber-tempered pottery, lived mainly along the St. Johns River, where their large shell middens indicate the use of almost all the available forms of Mollusca and animals for food. Evidence of their residence along the Atlantic coast is scanty but two sites have been examined and one more is reported. These two sites, one near Malabar on the beach ridge (Rouse, MS.) and the other on the west shore of Halifax River north of Ormond (Blatchley, 1902),[7] are unique in that they are mainly composed of coquina shells (*Donax* sp.) with occasional moon shells. Other shells are uncommon but include fresh-water forms and occasional oysters. The latter site is an unusually large deposit, being over 100 yards in length and up to 12 feet in depth, while the former is much shallower.

The composition of these sites is unusual because other archeological sites on this coast are predominantly formed of oyster shells, with only occasional small pockets of coquina shells. Moreover, the oyster

[6] Personal communication from L. M. Hardy of South Bay, a University of Florida student, July 10, 1947. Unfortunately, high water made it impossible to examine these sites in the 1947 summer season.

[7] Excavations here in the summer of 1947 by the Florida Park Service will give us much more data when the results are studied.

shell heaps are all of the St. Johns I and II periods dating from a later time (Fig. 1). Therefore, the difference in composition of these sites has temporal significance.

It seems probable that if oysters were available in quantity they would have been eaten by the Archaic peoples. They certainly showed little selectivity for foods on the St. Johns, and the occasional oyster shell in the coastal middens indicates that they were used when available. Under present ecological conditions (before dredging) and for some time previous, judging from the St. Johns I and II shell heaps, oysters were abundant in the coastal lagoons. By inference from their absence in the early sites, it seems probable that at the time these middens were deposited oysters were not available in quantity.

A successful oyster habitat is one that has the proper concentration of brackish water; therefore oysters usually grow in large bays and estuaries where fresh water constantly mingles with salt water. If this proper habitat was not available in Archaic times then the water must have been either too fresh or too salty. The possibility of its being too salty is not so probable in view of the lower sea level, unless there was a period of drought which reduced the supply of fresh water from the interior. It is more probable that the level of the sea was enough lower (perhaps no more than a couple of feet) to allow fresh water or only slightly brackish water to stand in these shallow lagoons. A similar situation could be the result of greater runoff, from increased precipitation, in the feeding streams. However, the shallowness of these coastal lagoons favors the former theory. Reinforcing evidence for this is the fact that a slightly lower sea level would be accompanied by a steeper gradient in the streams emptying into the lagoons, which would probably have resulted in a greater discharge of fresh water. In this flat country with the short streams such a change in gradient would be of importance.

Another possible explanation for the freshness of lagoon water takes into consideration the alternate opening and closing of inlets along the coast. This is an observed situation noted from the late eighteenth century (Romans, 1775: 287) to the present. However, inlet closing would produce purely local phenomena while we are dealing with areas as far apart as Ormond and Malabar, but which appear to share the same ecological situations.

Another possibility, which seems least probable to the writer, is that there was little or no change in depth and salinity of the coastal lagoons and that the absence of oysters must be due to other causes. In event of such a situation the possibility of some catastrophe killing the oysters cannot be ignored. Cold waves, salinity changes, and micro-organisms are known to have caused much damage among fish, although the damage to invertebrates is not well known (Gunter, 1947). Such disasters would be much more severe in the coastal lagoons than along the open Atlantic. Thus Mollusca such as the coquina would be less damaged.

It has been suggested (personal communication, Martin Burkenroad, January 1948) that considerable time might have been necessary after the water had reached the proper salinity before oysters would have been numerous. This would have depended on the nature of the bottom; neither a very sandy nor a very muddy situation would have been conducive to a rapid growth of oyster beds. Under such conditions they would have developed slowly until the dead shells finally produced the proper base for an extensive growth.

In summary we can reconstruct the situation as follows: In late Archaic times—the Orange and Tick Island periods (Fig. 1)—there was little occupation of the north Atlantic coast of Florida. The few people there made shell middens of coquina shells gathered on sandy beaches. Because the coastal lagoons were too fresh, oysters were not common. In a few localities, perhaps at the mouths of inlets, some oysters were available and these were eaten when found. The freshness of the coastal lagoons may have been due to a number of factors, but the most probable is the lower sea level, with the possibility of increased precipitation being an additional factor.

The problem of local ecological changes has been considered to some extent in

studies of the famous Vero and Melbourne sites. Data on these finds are being reexamined and evaluated by Irving Rouse (MS.) in terms of the newer ecological studies. It is probable that the history of these sites is closely tied to changes in the Indian River.

In the northern Everglades around the south shore of Lake Okeechobee, peat profile studies have disclosed considerable local ecological changes (Dachnowski-Stokes, 1930). Alternate low and high water stages are indicated by the sediments. This is mentioned here because of the evidence of deep archeological sites in these sediments (see the previous section). Unfortunately it is not clear if these variances represent local shoreline or other conditions or whether they are an expression of a broader climatic fluctuation. An examination of the biota of these beds might be fruitful.

Changes in faunal composition.—The West Indies top shell, *Livona pica* Linnaeus, is an abundant shell in many middens along the lower east coast of Florida. It has been seen in almost every archeological site examined between Key Largo and Sugarloaf Key in Monroe County and in numerous sites from Hillsborough Inlet north to Singers Island in Palm Beach County. This distribution coincides with the range of favorable habitat; that is, a rocky shore. These sites were occupied by the Indians in Glades II and III times, circa 1000–1500 A.D. (Fig. 1).

The presence of this shell is of considerable interest because, with the exception of a couple of doubtful records, this mollusk is not now found in Florida (Clench and Abbott, 1943: 9). The present range of the species is the West Indies, and the nearest modern occurrence is their reported presence on Dog Rocks, Cay Sal Bank, not far southeast of the Florida Keys.

What is the significance of their presence? The large quantity of shell found in the sites and the close correlation of their occurrence with their natural rock shore habitat suggests that the shells were locally collected, presumably for food, in the immediate vicinity of the sites. It is of interest to the archeologist whether their extinction in Florida can be attributed to man, to disease, or possibly to some environmental change which caused the animal to contract its range. If the last is the answer, was it purely a local manifestation or was it an expression of a broader change?

Examples of *Anodonta imbecillis* Say (probably specimens of a local species closely related to *A. imbecillis*), a freshwater shell, are described from the Ormond Archaic midden. Blatchley (1902: 72–74) cites Simpson to the effect that the present range of this mollusk is not south of North Carolina.

On the Florida Gulf Coast the *Strombus gigas* Linnaeus, is not now present, although there are records of dead shells or occasional specimens.[8] However, they are reported to occur in shell mounds at Cedar Keys (Calkins, 1878: 228; Ecker, 1878: 101). No shells of this species were seen in shell middens here in the course of a brief visit to this region, but a more intensive study may confirm their presence. Most of these sites were occupied subsequent to 1000 A.D.[9]

Vertebrate remains have not generally been carefully identified in Florida archeology, but one excellent study does point out differences in faunal composition. At South Indian Field, west of Malabar, a wide variety of vertebrate bones were

[8] Worn dead specimens have been noted at Sanibel and Captiva Islands (Perry, 1940: 135). *Strombus costatus* rarely occurs in the vicinity of Tampa Bay (Simpson, 1887–89: 53).

[9] Evidence from other regions in the New World indicates that similar molluscan faunal changes have taken place in recent times. Oysters form a large part of Maine shell heaps, although they are now uncommon in that area. The scallop *Pecten* sp. is also found in these shell heaps although it now lives from Cape Cod to the southward, and the clam *Mercenaria mercenaria* is at present rare north of Cape Cod although it is abundant in Maine shell heaps (Morse, 1925: 430).

In shellheaps on the Pearl Islands, west of the Isthmus of Darién, there were found three species of shells, *Strombus peruvianus*, *Ostrea chilensis*, and *Solen* (*Tagelus*) *dombeyi*, which do not have that northern range at the present time. To complicate things further there was found another species, *Venus* (*Ventricola*) *rugosa*, whose present habitat is the Antilles (Linné, 1929: 128–129).

On the Rio Preto, a tributary of the Rio Grande da Conceicão in Brazil, *Azara* sp. shells were found (in middens) which are of a form not now occurring in the surrounding region (Koenigswald, 1905: 346; also see Serrano, 1946, Ihering, 1903, and Krone, 1914).

identified (Houck, MS.). Among them was an unworked jaw fragment of a beaver, *Castor* sp., found in the early Orange period (Fig. 1). This animal is not now found in the vicinity of the site, although beavers were reported in unspecified localities in northern Florida in Colonial times.[10]

Remains of the great auk have been found in a shell heap near Ormond (Hitchcock, 1902; Blatchley, 1902). Details of the find are lacking, but the identification is apparently well confirmed.[11] This is the same site previously mentioned which was recently excavated by the Florida Park Service.

Changes in faunal size.—Jeffries Wyman (1875: 14) first pointed out that *Ampullaria* and *Paludina* shells (now known as *Pomacea* and *Viviparus* respectively) much larger than those now known, were to be found in shell heaps on the St. Johns River. He gives measurements which illustrate this clearly. Clarence B. Moore substantiated Wyman's findings by discovering even larger examples. However, he went further, pointing out that there has been considerable change in shell size, with the oldest and most modern being similar in size, while those of an intermediate period were larger (Moore, 1892: 921–922; 1893: 115).

It has not been possible to equate precisely Moore's old, middle, and late periods of shell change with the present chronology (Fig. 1), but a rough approximation is possible. There is little question that the first or oldest period with small size shells is the equivalent of the preceramic horizon, for he clearly states this. The period with the largest shells certainly includes in part the Orange and Tick Island horizons (see the Orange Mound, Moore, 1893: 616). However, the other sites listed by Moore as having large shells appear to have been occupied in part into St. Johns II times. Whether these large shells occur in that late horizon is not clear. But it does appear from the data that at least by some time in the St. Johns II horizon, the large size shells disappeared and the mollusks reverted to a size comparable to that now attained.

In association with the large size *Viviparus georgianus* of the middle period was a new form *Viviparus georgianus* var. *altior* Pilsbry (1892: 142). Moore (1892: 922) notes that the proportions of aperture to height of the *Viviparus* changed, but it is not clear whether this new variety represents the change or whether it is within the regular *Viviparus georgianus*.[12]

Data on mammals are limited, but deer bones from South Indian Field appear to represent individuals much larger and more massive than the present range of Florida deer. The remains of the round-tailed muskrat, *Neofiber alleni* True, are also much larger than contemporary forms, so much so that Houck (MS.) has expressed the possibility that they may represent a new variety.

Climatic change as evidenced by vegetation.—The well-known royal palms on the St. Johns River reported by Bartram (1940: 113) are a good example of what may be a recent climatic change in the past 200 years. The modern (circa 1900) natural range of the royal palm is twofold. One area of scattered occurrences is from Little River, Dade County, south and westward beyond Royal Palm Park to the Cape Sable region. In this spread of distribution they are closely associated with tropical vegetation. The other region is the southern end of Fakahatchee Slough or Strand in Collier County. Here the palms flourish in great numbers, reaching 80 to 100 feet in height, but in a temperate cypress and water-oak association. Strangely enough, a thatch palm is also found here. Between these two areas is the small group of palms on Lostmans River.

The most obvious explanation for the presence of the royal palms on the St. Johns would be that they made their northern extension during a warm period and then held on in favorable localities

[10] It may be noted that an extinct form of mink has been described from Maine shell heaps (Prentiss, 1903; Loomis, 1911).

[11] Although the great auk has long been extinct in New England, bones of the bird are very common in Maine shell heaps (Loomis and Young, 1912).

[12] Comparable changes in proportion have been noted in Maine shell heaps and elsewhere in the world in other species of shells (Morse, 1882; 1925).

until cold weather finally killed them off, moving their range southward. It is possible that, once established, they can survive a long time in a nontropical environment (as in Collier County), and that the climatic change that resulted in their extinction in north Florida actually was begun sometime before Bartram's visit in 1773.

CONCLUSIONS

A series of situations has been presented showing changes in the Recent ecology of Florida. These were either observations of early travelers or are data derived from archeological excavation. The changes included differences in sea level, coastal ecology, and in flora and fauna.

At best, much of the value of these data is to awaken interest and to stimulate further work. Because of the nonscientific method of gathering, most of the changes described can not be used for critical work. However, many of these finds could be duplicated under controlled collecting conditions.

The work at South Indian Field can serve as a model for further work, especially when biological and geological specialists are included in the research program. At this site every fragment of animal bone was saved and when possible was identified (Masius, MS.; Houck, MS.). As a result, stratigraphic data, which are tied to the cultural sequence can be given for the animal remains. The detailed survey and testing of Rouse (MS.) clearly bring out the unusual nature of the site in relation to the physical environment.

The future of Recent ecological work in Florida appears to be promising. The very nature of the environment on the border between tropical and temperate zones, plus a long low coastline must have resulted in many changes since the Pleistocene. It is probable that this survey has pointed out only a small amount of the information to be derived in conjunction with archeological work.

To gain the utmost ecological data from archeological work will require real cooperation. The archeologist whose interest is usually only cultural history is loath to collect all animal materials. He has found from experience that few naturalists are equipped to identify or even interested in identifying zoological material, which is often in very fragmentary condition. However, if given any encouragement he will probably be found eager to cooperate in collecting non-cultural material, for the archeological awareness of their value is growing.

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CHEMISTRY.—*Purification of uranium oxide.*[1] JAMES I. HOFFMAN, National Bureau of Standards.

Early in the summer of 1941 Leo Szilard[2] gave a sample of impure uranyl nitrate to the author and requested that the uranium be separated from everything else. It was his desire to obtain the residue, after the removal of uranium, for measurements of neutron absorption. During the same period samples of impure uranium oxide were sent to the National Bureau of Standards for chemical analysis. For both purposes it was desirable to use a solvent that would dissolve the bulk of the uranium without dissolving any of the other substances. The solubility of uranyl nitrate in ethyl ether, first reported by E. Peligot,[3] suggested its

[1] Received April 28, 1948. The information covered in this paper will appear at a later date in Division VIII of the Manhattan Project Technical Series.

[2] Member of Power Production Subsection of the Uranium Committee. See *Atomic Energy*, by Henry D. Smyth, Princeton University Press, 1945.

[3] Ann. Chim. Phys. (3) **5**: 5. 1842.

use for extraction of uranium as the nitrate, somewhat as ether is used in steel analysis for the extraction of ferric chloride. This extraction had been successfully applied in 1939 for separating uranyl nitrate from rhenium and certain rare earths in work on the determination of rhenium and molybdenum,[4] but, because of the conflicting statements concerning the solubility of the rare earth nitrates in ether,[5] it was obvious that experimental work was necessary, especially since Szilard stated that certain members of the rare earth group are strong neutron absorbers.

The work herein described is not intended to give the procedure finally used in large-scale production of uranium or the methods used in the various laboratories of the Manhattan Area. Many improvements in procedure have been made since this preliminary work was done.

EXPERIMENTAL

The bulk of the uranium was extracted with ether from 100 g of uranyl nitrate, $UO_2(NO_3)_2 \cdot 6H_2O$, to which had been added 5 ml of water and "rare earth" nitrates (equivalent to 0.0084 g of oxides) containing cerium, praseodymium, neodymium, erbium, gadolinium, terbium, dysprosium, holmium, erbium, ytterbium, lutecium, scandium, yttrium, lanthanum, and thorium. After removal of most of the uranium, the combined "rare earths" were determined in the residual water solution by precipitating them as fluorides, converting the fluorides to sulphates, then precipitating as oxalates, and igniting the oxalates to "rare earth" oxides. These oxides weighed 0.0086 g. In this particular case the uranium extracted by the ether was not examined for impurities, but it was evident that extraction of uranyl nitrate with ether should be a good starting point for the purification of uranium.

To obtain a quick answer to the possibility of using ether for the purification of uranium a nitric-acid solution of the elements listed in mixture A[6] in nitric-acid solution was evaporated as far as possible on the steam bath. The dry residue was extracted with 100 ml of ether, the ether was washed twice with 5 drops of water, and then the uranium in the ether was converted to oxide.

Qualitative spectrochemical analysis showed that this oxide contained only calcium, magnesium, and silicon, besides uranium. These encouraging results prompted further experiments, which formed the basis for the procedure given in the following section.

PROCEDURE USED FOR THE PURIFICATION OF URANIUM OXIDE

Fifty grams of U_3O_8 was transferred to a 600-ml beaker, 75 ml of diluted nitric acid (1 volume of concentrated nitric acid, sp. gr. 1.42, diluted with 1 volume of water) was added, and the beaker was placed on the steambath until all action ceased. The insoluble matter was removed by filtration, and the residue was washed four or five times with diluted nitric acid (1 volume of nitric acid, sp. gr. 1.42, diluted with 20 volumes of water). The filtrate and washings containing the uranyl nitrate were evaporated to dryness on the steambath. To the *cooled* and *dried* residue in the beaker 5 ml of water and 100 ml of ethyl ether were added, and the beaker was swirled until the uranyl nitrate was dissolved. The large quantities of impurities caused the aqueous phase in the bottom of the beaker to have the appearance of an emulsion, but this did not interfere in separating the layers be-

[4] Ether extraction of uranyl nitrate actually was first suggested to the author by the work of W. F. Hillebrand, U. S. Geol. Surv. Bull. **78**: 47. 1891, and such extractions were in use in our laboratory during the 1930's. Although the fact that uranyl nitrate could be extracted with ethyl ether was known for many years prior to the work recorded in this paper (see references in footnotes 3 and 5), data on the neutron-absorbing elements in atomic-energy work were of course not available.

[5] R. C. Wells, Journ. Washington Acad. Sci. **20**: 146. 1930; F. Soddy and R. Pirret, Phil. Mag. (6) **20**: 345. 1910; W. F. Hillebrand, U. S. Geol. Surv. Bull. 78: 47. 1891; C. W. Davis, Amer. Journ. Sci. (5) **11**: 20. 1926.

[6] Mixture A consisted of 2.5 g of uranium metal dissolved in an excess of nitric acid. To this was added as nitrates 2.5 mg each of copper, antimony, lead, aluminum, lithium, zirconium, indium, gallium, bismuth, potassium, dysprosium, cadmium, gadolinium, chromium, magnesium, holmium, cobalt, tin, calcium, and 10 mg of a mixture of "rare earths" known to contain cerium, lanthanum, scandium, praseodymium, thorium, and yttrium.

cause it was possible to pour the ether into a separatory funnel without mixing with the water layer.

The beaker was washed three times with 5-ml portions of ether, which were likewise transferred to the separatory funnel. The funnel was stoppered and shaken vigorously for ½ to 1 minute. After allowing the liquid to stand 3 minutes, a few drops of water appeared in the bottom of the separatory funnel. This water was drained into the beaker that originally contained the ether

TABLE 1.—SPECTROCHEMICAL ANALYSIS[1] OF PRODUCTS OBTAINED IN THE PURIFICATION OF URANIUM OXIDE OR URANIUM FROM ORE CONCENTRATES BY THE PROCEDURE DESCRIBED HEREIN

Element	U_3O_8 #155			U_3O_8 #181			Carnotite ore[2] concentrate		Pitchblende ore[2] concentrate	
	Original oxide	Water extract	Purified oxide	Original oxide	Water extract	Purified oxide	Original ore concentrate	U_3O_8 obtained	Original ore concentrate	U_3O_8 obtained
Ag	T	W	T	VW	W	T	T	T	T	T
Al	VW	W	VW	VW	W	VW	S	—	S	—
As	W	M	—	W	W	—	—	—	—	—
Au	—	T	—	VW	VW	—	T	—	—	—
B	T	VW	—	T	W	—	—	T	T	—
Ba	—	—	—	—	VS	—	M	—	W	—
Be	—	—	—	—	—	—	—	—	VW	—
Bi	VW	W	—	VW	W	—	—	—	W	—
C										
Ca	VS	W	—	W	M	T	VS	T	S	—
Cb	—	—	—							
Cd	—	—	—	—	—	—	—	—	—	—
Ce	—	W	—	—	W	—				
Co	—	—	—	W	M	—	W	—	VW	—
Cr	—	VW	—	—	VS	—	—	—	T	—
Cs	—	—	—	—	—	—				
Cu	VW	M	T	W	M	T	T	T	T	T
Dy	—	S	—	—	S	—				
Er	—	M	—	—	M	—				
Eu	—	M	—	—	M	—				
Fe	W	M	VW	W	M	VW	S	M	S	—
Ga	—	—	—							
Gd	—	M	—	—	M	—				
Ge	—	—	—	—	—	—	—	—	—	—
Hf	—	—	—				—	—	—	—
Hg	—	—	—	—	—	—	—	—	—	—
Ho	—	M	—	—	M	—	—	—	—	—
In	—	—	—	—	VW	—	—	—	—	—
Ir	—	—	—							
K	T	W	—	W	M	—				
La	—	T	—	—	T	—			—	—
Li	—	T	—	—	VW	—				
Lu	—	VW	—	—	VW	—				
Mg	W	W	T	W	W	VW	M	T	M	T
Mn	VW	W	—	W	W	—	W	—	W	—
Mo	W	M	W	W	M	—	—	—	VW	—
Na	W	M	T	M	S	T				
Nd	—	W	—	—	W	—				
Ni	—	VW	—	VW	W	—	—	—	—	—
Os	—	—	—		—		—		—	
P										
Pb	VW	W	—	W	M	—	VW	—	M	—
Pd	—	—	—		—		—		—	
Pr	—	W	—	—	W	—				
Pt	—	—	—	—	W	—	—			
Ra										
Rb	—	—	—	—	—	—				
Re	—	—		—		—	—		—	
Rh										
Ru	—	—	—		—		—		—	
Sb	W	M	—	W	M	—	—	—	—	—
Sc	—	W	—	—	W	—			—	
Si	M	M	VW	M	W	W	S	VW	W	VW
Sm	—	W	—	—	W	—				
Sn	—	VW	—	—	—	—	—	—	VW	—
Sr	—	—	—	—	VW	—	W	—	VW	—
Ta	—	—	—		—				—	
Tb	—	M	—	—	M	—				
Te										
Th	—	—	—	—	—	—	—		S	
Ti	—	—	—		—		—			
Tl	—	—	—	—	—	—	—	—	W	—
Tm	—	W	—	—	W	—			—	—
U	VS	VS	VS	VS	VS	VS	VS	VS	VS	VS
V	VW	W	—		VS		VS		W	—
W	—	—	—						W	—
Y	—	VS	—	—	VS	—			M	—
Yb	—	M	—	—	M	—				

NOTE.—The designations VS and S correspond to major constituents (greater than 1 percent); M and W to minor constituents (1 to 0.01 percent); and VW, T, and FT to trace constituents (less than 0.01 percent). The absence of a designation indicates that a test was not made for that element.

[1] By V. F. Scribner and H. R. Mullin.

[2] The water extracts contained rare earths, but no attempt was made to identify them individually.

solution. Five ml of water was now added to the solution in the separatory funnel, the mixture was shaken vigorously, and the solution was again allowed to stand until two layers formed. The aqueous phase was drained into the beaker that originally contained the ether solution. The washing with another 5-ml portion of water was repeated once more.

To convert the purified uranyl nitrate to oxide a little water was added to the ether, the ether was cautiously evaporated, and the residue was ignited to U_3O_8 at 1000°C. It was afterward found preferable to add 20 ml of water to the ether solution, shake vigorously for 1 minute, and allow the liquid to separate into two layers. The water layer containing the uranium was drained into a suitable dish, and the extraction with 20-ml portions of water was repeated until the ether above the water was colorless. Three or four such extractions were sufficient to remove the uranium. The combined water extracts were evaporated to dryness, and the uranyl nitrate in the residue was ignited to U_3O_8 at 1000°C. The ether from which the uranyl nitrate had been removed was suitable for future extractions.

The procedure was also applied to the extraction of uranium from pitchblende and carnotite ore concentrates by digesting the ore concentrate with nitric acid, evaporating to dryness, and extracting the residue with ether. The efficacy of this method of purification is shown in Table 1. The table shows that in many cases impurities that were not detected in the original oxide were concentrated and detected in the water extract. Note especially Ce, Co, Cr, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sc, Sm, Tb, Tm, and Y.

DISCUSSION

It was evident that the purification of crude uranium oxide and the removal of uranium from ore concentrates by conversion of the uranium to uranyl nitrate and extraction with ether had possibilities because practically all impurities were removed in a single operation. Tests by L. F. Curtiss[7] indicate that practically none of the radium in the original ore was extracted by the ether.

Under stress of wartime conditions not all the possible confirmatory tests were made, but, as a check on removal of the rare earths, the purified oxides obtained from no. 155 and no. 181, Table 1, were put through a second purification by the same procedure. The water extracts in this case showed no rare earths. Tests by K. D. Fleischer indicated that if 0.5 mg of "rare earth" oxides had remained in the purified oxide, a positive test would have been obtained here. These tests showed also that by this simple procedure the combined "rare earths" in the purified oxide were reduced to less than 5 parts per million. The spectrochemical tests showed that not more than 0.5 part of cadmium or boron per million remained in the purified material.

SUMMARY

A procedure is given for the purification of uranium oxide by converting the oxide to the nitrate and partitioning the nitrate between a large amount of ether and a relatively small amount of water. In modified form, the procedure was found to be applicable to pitchblende and carnotite ore concentrates, as indicated in Table 1.

[7] Chief of Section on Radioactivity at the National Bureau of Standards.

BOTANY.—*Notes on North American Leguminosae.*[1] FREDERICK J. HERMANN, U. S. Department of Agriculture.

In the course of routine identification of collections of Leguminosae sent to the U. S. Department of Agriculture over a period of several years the advisability of proposing the following transfers and changes in status has become apparent. Included also is a diagnosis for an apparently hitherto undescribed *Phaseolus* from Mexico.

[1] Received March 25, 1948.

Acacia schaffneri (S. Wats.), comb. nov.

Pithecolobium schaffneri S. Wats., Proc. Amer. Acad. **17**: 352. 1882; *Samanea schaffneri* Macbride, Contr. Gray Herb. **59**: 2. 1919; *Poponax*

schaffneri Britton & Rose, N. Amer. Flora **23**: 89. 1928.

Acacia pinetorum, nom. nov.

Vachellia peninsularis Small, Man. Southeastern Flora 654. 1933; not *Acacia peninsularis* (Britton & Rose) Standl., Field Mus. Publ. Bot. **11**: 158. 1936, based on *Senegalia peninsularis* Britton & Rose, N. Amer. Flora **23**: 116. 1928.

Schrankia angustisiliqua (Britton & Rose), comb. nov.

Leptoglottis angustisiliqua Britton & Rose, N. Amer. Flora **23**: 143. 1928.

Schrankia chapmani (Small ex Britton & Rose), comb. nov.

Leptoglottis chapmanii Small ex Britton & Rose, N. Amer. Flora **23**: 141. 1928.

Desmanthus pringlei (Britton & Rose), comb. nov.

Acuan pringlei Britton & Rose, N. Amer. Flora **23**: 134. 1928.

Caesalpinia colimensis, nom. nov.

Brasilettia glabra Britton & Rose, N. Amer. Flora **23**: 321. 1920, not *Caesalpinia glabra* (Mill.) Merrill, Philipp. Journ. Sci. **5**: 54. 1910.

Caesalpinia pumila (Britton & Rose), comb. nov.

Guaymasia pumila Britton & Rose, N. Amer. Flora **23**: 322. 1930; *Caesalpinia gracilis* Benth. ex Hemsl., Diag. Pl. Nov. 9. 1878, not Miq., Fl. Ind. Bat. **1**: 110. 1855.

Dalea tuberculina (Rydb.), comb. nov.

Parosela tuberculina Rydb., N. Amer. Flora **24**: 89. 1920.

Petalostemum candidum Michx., var. **oligophyllum** (Torr.), comb. nov.

Petalostemum gracile var. *oligophyllum* Torr. in Emory, Notes Mil. Rec. 139. 1848; *P. candidus* var. *occidentalis* Gray ex Heller in Britton & Kearney, Trans. N. Y. Acad. Sci. **14**: 33. 1895; *Petalostemon oligophyllus* "Torr.," Smyth, Trans. Kans. Acad. Sci. **15**: 61. 1898; *P. occidentale* (Gray) Fernald, Rhodora **39**: 28. 1937.

Tephrosia virginiana (L.) Pers., var. **leucosericea** (Rydb.), comb. nov.

Cracca leucosericea Rdyb., N. Amer. Flora **24**: 163. 1923; *Tephrosia leucosericea* (Rydb.) Cory, Rhodora **38**: 406. 1936.

Tephrosia ambigua (M. A. Curtis) Chapm., var. **intermedia** (Small), comb. nov.

Cracca intermedia Small, Bull. Torr. Bot. Club **21**: 303. 1894.

Astragalus tenellus Pursh, var. **strigulosus** (Rydb.), comb. nov.

Homalobus strigulosus Rydb., Bull. Torr. Bot Club **34**: 420. 1907; *Astragalus tenellus* f. *strigulosus* Macbr., Contr. Gray Herb. **65**: 34. 1922.

Astralagus michauxii (Kuntze). comb. nov.

Tragacantha michauxii Kuntze, Rev. Gen. 941. 1891; *A. glaber* Michx. 1803, not Lam. 1783.

Astragalus ceramicus Sheld., var. **filifolius** (Gray), comb. nov.

Astragalus pictus var. *filifolius* A. Gray, Proc. Amer. Acad. **6**: 215. 1864; *Psoralea longifolia* Pursh, Fl. Amer. Sept. 741. 1841, not *Astragalus longifolius* Lam. 1783; *Astragalus mitophyllus* Kearney, Leafl. W. Bot. **4** (8): 216. 1945.

The above combination is necessitated by the fact that Gray's *Astragalus pictus* (Proc. Amer. Acad. **6**: 214. 1864) is a later homonym of the validly published *A. pictus* Boiss. & Guillardot in Boiss., Diagn. Pl. Orient. Ser. 2, **3** (6): 55. 1859, so that *A. ceramicus* Sheld. must be taken up in its stead for our American plant. Although Dr. Kearney's epithet is available for Gray's var. *filifolius* when treated in specific rank, the proportion of specimens intermediate between it and *A. ceramicus* that have come to the attention of the writer leads to the conclusion that varietal status may be more appropriate for it.

Centrosema arenicola (Small), comb. nov.

Bradburya arenicola Small, Fl. Southeastern U. S. 651. 1903.

Desmodium arenicola (Vail), comb. nov.

Meibomia arenicola Vail, Bull. Torr. Bot. Club **23**: 140. 1896; *Hedysarum lineatum* Michx., Fl. Bor. Amer. **2**: 72. 1803, not L. 1759; *Desmodium lineatum* (Michx.) DC., Prodr. **2**: 330. 1825.

Although the name *Desmodium lineatum* (Michx.) DC. has been in general use for this plant it can be maintained only in spite of Article 61. An unfortunate consequence of this rule, as it now stands, is that a later homonym is rendered permanently *hors de combat,* even though the specific epithet upon transference to another genus would not constitute a homonym in its new context.

Rhynchosia simplicifolia (Walt.) Wood, var. **intermedia** (T. & G.), comb. nov.

Rhynchosia tomentosa β intermedia T. & G., N. Amer. Fl. **1**: 285. 1838; *R. intermedia* (T. & G.) Small, Man. Southeastern Flora 715. 1933.

Phaseolus neglectus, sp. nov.

Herba volubilis; stipulis lineari-oblongis, 3–5 nerviis, 5–6 mm longis, rigidis; stipellis lineari-oblongis, 2–3 mm longis; foliolis deltoideo-acuminatis vulgo plus minusve lobatis; pedunculis 5–11 cm longis: bracteis persistentibus, rigidis, 6–9 mm longis, 5-nerviis, subtus plerumque pilosis: pedicellis tenuibus glabratis; bracteolis caducis, uninerviis; calyce campanulato-cupuliformi; corolla 20 mm longa; vexillo obovato, valde emarginato; alis orbiculari-ovatis; ovario dense piloso.

Herbaceous vine; stems slender, sparsely puberulous with reflexed hairs to glabrate; stipules linear-oblong, 3–5 nerved, 5–6 mm long, rigid; petioles puberulous to glabrate, 3–6 cm long; stipels linear-oblong, rigid, 2–3 mm long; leaflets 3, membranaceous, deltoid-acuminate, sparsely puberulent above, glabrous to sparsely puberulent beneath, 2–6 cm long, 2–4.5 cm wide, lobed (often only shallowly so or even entire), the median 3-lobed, the lateral 2-lobed, the lobes round-ovate and generally shallow; peduncles slender, 5–11 cm long, 11–25-flowered; bracts persistent, green, lanceolate-acuminate, firm, 5-nerved, generally more or less pilose beneath, sparingly so to glabrate above, 6–9 mm long, 1–1.5 mm wide at base; pedicels slender, glabrate, 3.5–5 mm long; bracteoles caducous, green, narrowly linear-lanceolate, one-nerved, glabrous, 2–2.5 mm long; calyx campanulate-cupuliform, 2.5–3.5 (lower lip up to 5) mm long, very sparingly ciliolate, the lower lip irregularly pilose, prominently 3–lobed with median lobe 2.5 mm long, acute, upper lip very shallowly 2–lobed; corolla 20 mm long, pale salmon to light blue; standard obovate, 16 mm long, 12 mm wide, deeply emarginate, the upper half reflexed; wings orbicular-ovate, abruptly contracted into a broad claw, its lower half adnate to the keel; keel tubular, with two complete coils; free stamen with a reniform enlargement above the base; style-beard extending around the first coil; stigma lateral; ovary linear, densely pilose.

Nuevo León, Mexico in oak woods along trail up Sierra de la Cebolla from La Trinidad, Municipio de Montemorelos, *C. H. Muller* 2881, Aug. 20, 1939 (TYPE—U. S. National Arboretum Herbarium).

Nearest allied to *Phaseolus foliaceus* Piper, of the Sierra Madre. From this it differs in its longer, linear-oblong, rather than triangular-lanceolate stipules; its 5-nerved, linear-lanceolate bracts which are pilose below; its shallowly lobed leaflets; longer peduncles bearing racemes with more numerous flowers; campanulate-cupuliform calyx which is almost imperceptibly ciliolate; corolla 20, rather than 10, mm long; obovate, deeply emarginate standard; and orbicular-ovate wings.

MYCOLOGY.—*Two new species of* Physarum.[1] G. W. MARTIN, State University of Iowa.

The two species of *Physarum* here noted were included in the extensive collections of Myxomycetes made by William Bridge Cooke on Mount Shasta, Calif., and submitted by him for identification. One of them proves to be identical with two old collections from Mount Rainier, Wash., which have been in this laboratory for many years awaiting determination. Both appear to be clearly distinct from any recognized species in this large genus.

[1] Received November 5, 1947.

Physarum rubronodum, sp. nov.

Sporangiate, globose to obovate or pulvinate, sessile or borne on weak, strandlike stalks produced as extensions of the hypothallus, pinkish brown, or dark when lime is scanty in peridium, 1–1.5 mm in diameter, densely clustered on a common hypothallus; peridium double, the outer layer cartilaginous, calcareous, shining, crustose, smooth except for a coarse overlying reticulation or, when lime is scanty, dark and lacking the reticulation, the inner layer membranous, closely applied, colorless,

iridescent; hypothallus prominent, silvery to yellow, venose, the veins often projecting as stalk-like extensions on which sporangia are borne; capillitium profuse, close-meshed, bearing large fusiform or irregularly angular scarlet or pinkish nodes, most of the junctions limeless; spores nearly black in mass, dark violaceous brown by transmitted light, slightly paler on one side, densely and somewhat ir-

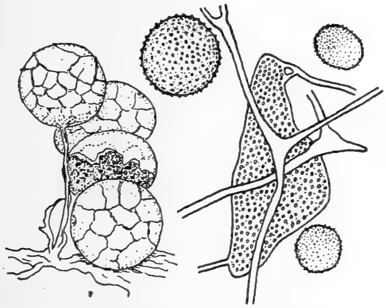


FIG. 1.—*Physarum rubronodum.* Left, group of sporangia (*Cooke* 15671a) on hypothallus, ×12; right, detail of capillitium with two spores (*Cooke* 18126), ×520; above, spore of same, ×1,000.

regularly verrucose, globose, 11–13μ in diameter, or oval and correspondingly longer and narrower. Plasmodium scarlet or orange-red.

Sporangiis globosis vel obovatis vel pulvinatis, sessilis vel substipitatibus, miniato-brunneis, 1–1.5 mm diam., dense caespitosis sub hypothallo commune; peridio duplici, extus cartilagineo, calcareo, crustaceo, nitente, laeve praeter crasso reticulato; intus membranaceo, applicato, hyalino, iridescente; capillitio denso e filamentis hyalinis reticulato-anastomosatis, nodulis calcareis, magnis, fusiformibus vel irregulariter angularibus, coccineis vel miniatis multis axillis ecalcareix; sporis globosis vel subovoideis, atropurpureo-brunneis crebro grosseque tuberculatis 11–13μ diam. Plasmodio coccineo vel aurantiaco.[2]

CALIFORNIA: Mount Shasta, 8,000 feet, elev., July 7, 1941, *W. B. Cooke* 15671a, TYPE. Same locality, June 29, 1947, *W. B. Cooke* 18126.

Physarum rubronodum is obviously close to *P. albescens* Macbr. Like that species, it has a crustose outer wall suggesting *Leocarpus*, and many of the sporangia are borne on strandlike extensions of the hypothallus. It differs in the pinkish-brown or dark peridium, in the striking scarlet nodes, in the somewhat smaller, warted rather than spiny spores, and in the scarlet or deep orange-red plasmodium.

Physarum auripigmentum, sp. nov.

Sporangiate, stalked, gregarious; sporangium globose, 0.4–0.6 mm in diameter, total height 0.6–1 mm., clear to opaque yellow (about lemonchrome of Ridgway); peridium membranous, closely covered by subcircular limy scales; dehiscence somewhat petaloid; columella none; stalk short, about half the diameter of the sporangium, cylindrical, expanded at the base, orange-red, limeless, translucent; hypothallus scarcely evident; capillitium dense, delicate, persistent, the nodes small, rounded, bright yellow, many of the junctions limeless and with numerous free, pointed ends; spores dark brown in mass, clear violet-brown by transmitted light, nearly smooth, (8.5–) 9.5–11 (–12.5)μ in diameter, Plasmodium unknown.

Sporangiis stipitatibus, gregariis, globosis, 0.4–0.6 mm diam., totis 0.6–1 mm altis, lucidis haud pellucidis luteis; peridiis membranaceis, squamis suborbiculatis calcareis applicatis; subfloriforme dehiscentibus; columella nulla; stipes brevis, attingens dimidium diametrosis sporangii, cylindraceus, expansus basi, aurantiacus, ecalcareus, translucidus; hypothallo quo

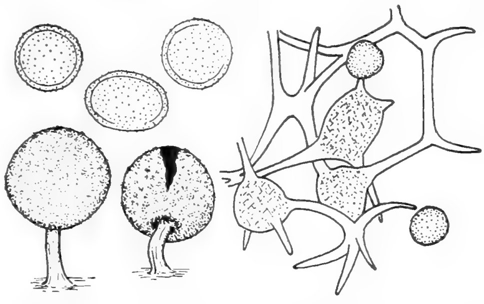


FIG. 2.—*Physarum auripigmentum* (*Cooke* 20099). Left below, two sporangia, ×60; right, detail of capillitium, with two spores, ×520; left, above, three spores, ×1,000.

vix sentiri; capillitio denso, delicato, persistente, nodulis parvulis rotundatis, luteis, multis axillis ecalcareis, apicibusque multiplicibus, apertis, acutis; sporis atro-brunneis, violaceo-brunneis pellucente, sublevibus, 9.5–11μ diam. Plasmodio ignoto.

CALIFORNIA: Mount Shasta, 8,000 feet elev., June 23, 1947, *W. B. Cooke* 20099, TYPE.

[2] I am indebted to Sister Mary Cecelia Bodman for assistance with the Latin diagnoses.

WASHINGTON: Longmire Springs, Mount Rainier, August 10–17, 1928, *D. B. Creager* S. U. I. 1722; Paradise Valley, Mount Rainier, August, 10–17, 1928, *D. B. Creager* S. U. I. 1723.

Physarum auripigmentum suggests *P. oblatum* Macbr. but differs in the scaly character of the peridium, in the shorter and brighter stalks without dark basal deposits, and especially in the dense capillitium, with its small, regular nodes, numerous lime-free junctions and conspicuous free ends.

ENTOMOLOGY.—*Synoptic revision of the United States scarab beetles of the subfamily Dynastinae, No. 5: Keys to tribes and genera.*[1] LAWRENCE W. SAYLOR, California Academy of Sciences.

This paper completes my studies covering a synoptic review of the United States dynastine scarab beetles, the preceding four parts having been published in this same JOURNAL.

A great deal of work, from a taxonomic standpoint, remains to be done in the American members of this tribe, especially in the Neotropical genera. Generic limits of such genera as *Ligyrus* and *Stenocrates*, as well as many others, must be thoroughly studied and the relative importance of such characters as the front male claws (enlarged or not), the dentition of the mandibles, and the usual sexual dimorphism must be better understood.

In the present studies I have had the cooperation of many institutions and individuals in obtaining material, or submitting material for identification: United States National Museum, through the courtesy of Drs. Wetmore and Chapin; the extensive collections of the California Academy of Sciences through its director Dr. Miller and its entomological curators Drs. Ross and Van Dyke; American Museum of Natural History through its curator Dr. Cazier; and many private individuals, among them Drs. Cartwright, Ritcher, Reinhard, and Sanderson, as well as Dr. Dampf of Mexico City. I have also received material from the Paris Museum through Dr. Paulian, and from the British Museum through Dr. Hinton and Mr. Arrow, to all of whom I am indebted for numerous past favors.

SUBFAMILY DYNASTINAE

Diagnostic characters.—Tarsal claws always *equal* in size, or at least so on the middle legs (one claw of the front pair is frequently enlarged in males of certain species); mandibles entirely corneous, and usually exposed beyond the clypeus (from dorsal view); mandibles frequently large and dentate externally; labrum hidden under the clypeus; clypeus more commonly acuminate apically, and dentate or edentate; scutellum normal, never greatly enlarged; sexes frequently dimorphic, the males frequently with tubercles or horns on either head or thorax or both, the females in many species likewise equipped; coloration usually some shade of black or brown, only very rarely with any metallic lustre; antennal club always relatively small and 3-segmented; ligula entirely connate with the mentum; abdominal spiracles diverging strongly behind; anterior coxae transverse, not prominent; stridulating organs frequently appear in many species, located on propygidium or inside the elytra; fifth ventral sternite and propygidium connate, the last spiracle on the suture between them; onychium between the tarsal claws commonly bisetose, varying to multisetose in certain genera.

KEY TO UNITED STATES TRIBES

1. Labial palpi inserted *behind* the mentum; body always *depressed* above; frequently with tubercles or horns on head or thorax; mid-disc of thorax often longitudinally impressed; hind tibia digitate or truncate at apex but not noticeably widened; first segment of hind tarsus with strong spine at apex; sexual differences hardly apparent.......................................PHILEURINI

   Labial palpi inserted *at the sides* of the ligular part of the mentum; body never strongly depressed, usually evenly convex dorsally; head and thorax horned or not; sexual characters noticeable in last abdominal sternite or front tarsal claw in all instances.......2
2. Head and thorax in both sexes entirely *unarmed, without* tubercles or carinae or horns, and never depressed or foveate; claw with the onychium always bisetose (never more

[1] Received September 3, 1947.

than two cilia); stridulating organs absent; male front claws in many species either enlarged or larger than in female; antenna often larger in male than female; tarsi cylindrical and usually elongate, never triangular; prosternal spine prominent behind the fore coxae .... CYCLOCEPHALINI

Head and thorax (either or both) armed with

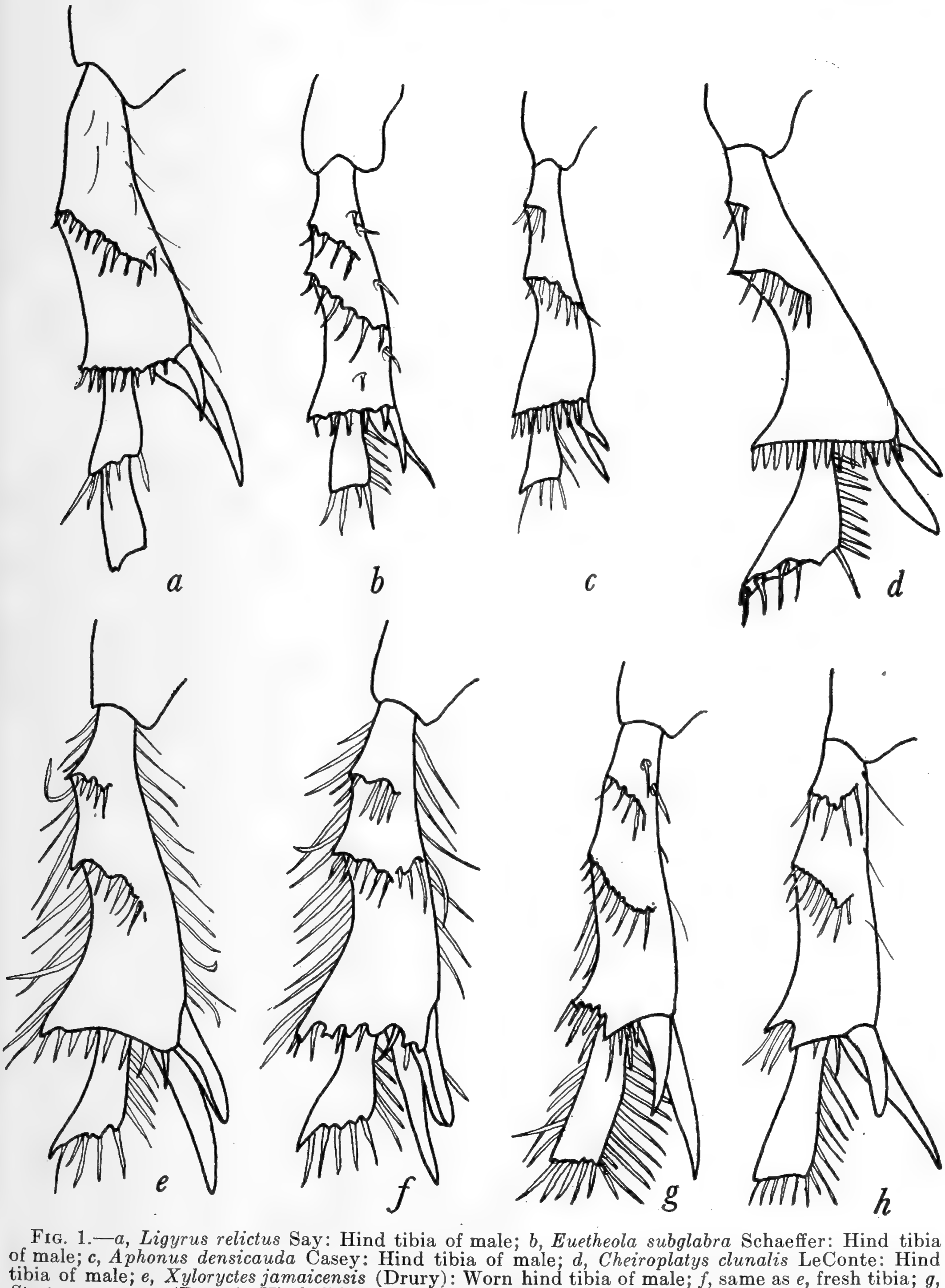


FIG. 1.—*a, Ligyrus relictus* Say: Hind tibia of male; *b, Euetheola subglabra* Schaeffer: Hind tibia of male; *c, Aphonus densicauda* Casey: Hind tibia of male; *d, Cheiroplatys clunalis* LeConte: Hind tibia of male; *e, Xyloryctes jamaicensis* (Drury): Worn hind tibia of male; *f*, same as *e*, fresh tibia; *g, Strategus antaeus* (Drury): Hind tibia of male; *h, Strategus mormon* Burmeister: Hind tibia of male.

horns or tubercles (on fore margin of thorax if nowhere else) in both sexes, and frequently foveate (*or* with strong head carina and large, well-rounded mandibles as in *Aphonides*); claw with onychium bisetose to multisetose; stridulating organs variable; other characters variable....................3

3. Onychium between claws bisetose to plurisetose; tarsal segments, especially basally, frequently triangular in shape; fore tibia and tarsus of *same length* in both sexes; stridulating organs frequently present; dorsal surface always *unicolorous;* never spotted or with dense hair....................ORYCTINI

   Onychium between claws always with three or more setae apically; tarsal segments elongate smooth, never triangular, the basal segment usually with a strong apical spine; front tibia and tarsus a little longer in the male than in the female (very distinct in neotropical species, but must be carefully compared in United States species); stridulating organs absent; dorsal surface either clothed with a fine *velvety* short hair, or spotted and speckled, only rarely entirely unicolorous in some females.................DYNASTINI

The genera of the tribes Phileurini and Dynastini were covered in Part 4 of this series, and the genera of the tribe Cyclocephalini in Part 1.[2] The tribe Oryctini was discussed in Part 2[3] and in Part 3[4] and was completed in Part 4[5]; these eight United States genera of Oryctini may be separated as follows:

KEY TO GENERA OF UNITED STATES ORYCTINI

1. Apex of hind tibia *uneven*, with sharp angulations or teeth (see Fig. 1, *g*, *f*); head frequently with horn (male) or large tubercle (female) (this character will place those specimens with worn tibia as in some *Xyloryctes*, as in Fig. 1, *e*.................2

   Apex of hind tibia moderately to strongly expanded, with *very fine* serrations (not sharp teeth) or entirely smooth (see Fig. 1, *a*, *d*); head *never* with horns, at most with a strong to weak transverse carina or a small tubercle 4

2. Clypeal apex acute and unidentate; mandibles large and exposed, and evenly *rounded*, never toothed; thorax never foveate or tuberculate; base of clypeus with a strong transverse carina (Texas and Arizona)..................................*Aphonides* Rivers

   Clypeus acute, bidentate or bluntly rounded (if acute, then the mandibles always distinctly emarginate or toothed externally, and thorax always foveate and tuberculate) 3

3. Mandibles usually hidden beneath the clypeus, or only edges exposed, and always unarmed externally; usually with 5 to 9 small teeth on outer apical margin of hind tibia..............................*Xyloryctes* Hope

   Mandibles always large, always well exposed, always armed externally with teeth or else right-angled in outline (*cessus*); apical margin of hind tibia usually with 1 or 2 sharp angulations, or 3 or 4 teeth..............................*Strategus* Hope

4. Clypeal apex acute, *unidentate;* clypeal base with an acute transverse carina; mandibles large and *tridentate;* thorax with fovea at midapex and a small tubercle in front of the fovea; color usually rufous..............................*Oxygrylius* Casey

   Clypeal apex distinctly *bidentate*, or evenly truncate, or very bluntly rounded, never with a single sharp point (*or* if somewhat pointed, then the mandibles small and nearly hidden under the clypeus); color variable..5

5. Clypeus with a distinct carina *just before* (i.e., practically *on*) the apex, this carina entire, or wide bidentate, or tridentate; front male tibia frequently edentate, the tibia unusually wide in both sexes and the emarginations between the external teeth very shallowly indicated, especially the two apical teeth..6

   Clypeus carinate or not; if carinate the carina located quite a distance *before* the apex; front tibia always strongly tridentate....7

6. Preapical clypeal carina *entire*, or *bidentate;* thorax and head tuberculate or not (Southwestern United States). *Cheiroplatys* Hope

   Preapical clypeal carina strongly to weakly *tridentate;* thorax not tuberculate, head rarely so (Eastern United States)..............................*Aphonus* LeConte

7. Mandibles definitely tridentate externally, the basal tooth often worn and barely visible; thorax not more than two-thirds the length of the elytra; color rufous to rufopiceous or rufocastaneous........*Ligyrus* Burmeister

   Mandibles *bidentate* externally (do not count lacinia tooth as mandibular!); thorax about three-fourths length of elytra; color always black....................*Euetheola* Bates

SUPPLEMENT

Euetheola subglabra Schaeffer

Since Part 2 of this series was published I have received a male specimen from Tepic, Mexico, from Dr. Chapin, of the U. S. National Museum; this has very worn mandibles and clypeus, but the genitalia are typical, and the thoracic punctuation is very minute and sparse but still visible on the center disc in a good light. I have also just recently mounted an additional pair (male and female) from "Compostella, Tepic, Nayarit, collected VI-24-40 at light by Morgan M. and L. W. Saylor"; these were mixed in with some un-

[2] Journ. Washington Acad. Sci. **35** (12): 378–386. 1945.
[3] Ibid. **36** (1): 16–22. 1946.
[4] Ibid. **36** (2): 41–46. 1946.
[5] Ibid. **38** (5): 176–183. 1948.

mounted *Dyscinetus* material, which they greatly resemble superficially. The female has not been described before and I am designating this specimen as the *Allotype:* Very similar to male except that it is a little larger (16 mm), the minute thoracic punctures are entirely absent over most of the center-disc, the apical half of the pygidium is smooth and very sparsely punctate and the apical half of the sixth sternite is entirely smooth and impunctate. It is interesting that nearly the entire abdomen (except for a single transverse setigerous row on each sternite near sides) and the metasternum (except at sides) are highly polished and entirely impunctate in both sexes. Both specimens remain in the Saylor Collection at the California Academy of Sciences.

ENTOMOLOGY.—*The Herbert H. Smith collection of South American Chalcidoidea described by W. H. Ashmead.*[1]

A. B. GAHAN, U. S. Bureau of Entomology and Plant Quarantine. (Communicated by E. A. CHAPIN.)

In his *Classification of the chalcid flies or the superfamily Chalcidoidea* (Mem. Carnegie Mus. **1** (No. 4, pt. 2): 394–551. 1904) W. H. Ashmead published results of his study of the Herbert H. Smith collection of South American chalcidoids, including a bibliographic catalogue of all the known South American species. Many new species were described, most of them based upon material in the Smith collection, but several of the included new species were based upon material in the United States National Museum, collected by Albert Koebele. In the bibliographic catalogue, citations were given for a number of species previously described by Ashmead from material in the Smith collection, these descriptions appearing in Insect Life **3:** 456. 1891; Proc. Ent. Soc. Washington **3:** 233. 1895, and **4:** 11–14. 1896; and Proc. U. S. Nat. Mus. **22:** 368–375. 1900. Also included were Ashmead's identifications of a number of species described by Walker, Westwood, Fabricius, Perty, and other authors.

Holotypes of 8 species and duplicate paratypes of 36 additional species, as well as duplicates of some of the determined species, were retained by Ashmead from the Smith collection. The remainder of the collection was returned to the Carnegie Museum, which had acquired it by purchase from the collector. There the collection remained practically undisturbed until 1934, when through the kind cooperation of the late Dr. Hugo Kahl, then curator of the section of entomology at Carnegie Museum, and with the consent of the Museum director, I was permitted to bring the whole collection to the United States National Museum for study. Though it still remained the property of Carnegie Museum, it has reposed in the National Museum since that date and while being used for reference has been kept, until very recently, in the original boxes and arrangement in which Ashmead left it.

Early in 1947, through collaboration with Dr. George E. Wallace, successor to Dr. Kahl at the Carnegie Museum, and with the approval of the authorities of both the Carnegie Museum and the National Museum, arrangements were completed whereby, in exchange for a representative collection of named North American chalcidoids, the entire Smith collection covered by Ashmead's paper, with the exceptions of one-half the duplicates in any series of paratypes or of determined specimens of any species, became the property of the National Museum. With consummation of the exchange the Carnegie Museum received a named collection of North American material comprising 412 species represented by 1,222 specimens and also a return of 22 paratypes representing 16 species and 84 specimens representing 19 determined species from the South American material. The National Collection acquires named representatives of 248 species made up of 192 holotypes, 79 paratypes (8 of which represent species the holotypes of which were already in the National Museum), and 156 determined specimens representing 48 species. Also included are 122 unidentified specimens, making a total of 549 specimens.

Unfortunately, the unique types of *Parencyrtus brasiliensis* Ashmead, *Pelorotelus coeruleus* Ashmead, *Horismenus corumbae*

[1] Received March 7, 1948.

Ashmead, *Euplectrus brasiliensis* Ashmead, and *Stenomesius dimidiatus* Ashmead have become dislodged from the mounting points and lost. Since the first two species are genotypes, their loss is doubly unfortunate. Also missing from the collection is the specimen (or specimens) of *Idoleupelmus annulicornis* Ashmead recorded from Santarém, Brazil. This species was originally described (Proc. Ent. Soc. Washington **4**: 13. 1896) from the Island of St. Vincent, West Indies, and the holotype is presumably in the British Museum.

The material from the Smith collection acquired by the National Museum has now been removed from the original boxes and placed in standard trays and drawers. While making the transfer I made the following notes regarding certain species:

Hemitorymus thoracicus Ashmead.—In my opinion this is not a monodontomerine. The type appears to be a typical *Torymus* and the genus *Hemitorymus*, therefore, a synonym. New synonymy.

Plesiostigmodes brasiliensis Ashmead.—The unique type is a male, not a female as stated in the description.

Spilochalcis tarsalis Ashmead.—The type is from Corumba instead of Chapada.

Spilochalcis persimilis Ashmead.—Type locality Santarém instead of Chapada.

Spilochalcis bimaculata Ashmead.—Described only in the key to species. The type, a female, is from Trinidad.

Spilochalcis nigropleuralis Ashmead.—The holotype female is from Trinidad. The only male associated with this female in the collection is from Corumba (not Chapada), Brazil, and does not entirely fit the description given of the male. It does not bear a name label and may or may not be the allotype.

Spilochalcis mayri Ashmead.—The type is from Corumba, not Chapada.

Spilochalcis urichi Ashmead.—No male is described, but included among the 12 specimens in the type series is one male. This is colored almost exactly like the females and not easily distinguished.

Spilochalcis lineocoxalis Ashmead.—The unique holotype is a male, not a female.

Spilochalcis chapadensis Ashmead.—In the key to species (p. 427) and on the name label, the name of this species is *chapadensis*, but heading the formal description (p. 443) it is given as *chapadae*. That the latter spelling is a lapsus is obvious, since the name *chapadae* had already been used for another species of *Spilochalcis* (p. 432). The name *chapadensis* should be retained for the species on p. 443.

Spilochalcis persimilis Ashmead.—The unique holotype is a male instead of a female.

Octosmicra nigromaculata Ashmead.—The locality is Corumba instead of Chapada.

Heptasmicra lineaticoxa Ashmead.—One paratype is from Maruru, the type and 2 paratypes from Santarém.

Metadontia similis Ashmead.—The unique holotype is a female instead of a male.

Pentasmicra brasiliensis Ashmead.—Described only in the key to genera. See article by Hugo Kahl (Ann. Carnegie Mus. **13**: 265. 1921).

Axima brevicornis Ashmead.—The male allotype and 4 male paratypes of this species do not appear to be the same species as the female holotype and the female paratype. Instead, these males all seem to me to be *A. koebelei* Ashmead.

Aximopsis morio Ashmead.—The type locality for this genotype species, not recorded by Ashmead, is Santerém, Brazil.

Isomodes brasiliensis Ashmead.—Only 4 of the 5 specimens recorded by Ashmead were found, the specimen from Santarém being missing.

Prodecatoma bruneiventris Ashmead.—The type series consists of 3 females and 1 male. In my opinion the 3 females represent 3 different species. The male allotype is labeled "*Prodecatoma flavescens* Ashmead. ♂ Type," but since no male was described for *flavescens* and since this male specimen agrees with the description of the male as given for *bruneiventris*, it is obvious that the labeling is a lapsus.

Neorilya flavipes Ashmead.—The type series, of which only 9 specimens can be located, is a composite made up of apparently 3 different species.

Rileya orbitalis Ashmead.—The unique holotype female is from Chapada instead of Santarém. A male in the National Museum collection from Chapada is labeled "*Rileya orbitalis* ♂, Type No. 8080." Ashmead may have originally associated this with the female holotype, but since no male is mentioned in the

description it should not be considered a paratype. This male is apparently not the same species as the holotype but appears to be identical with *Rileya insularis* Ashmead.

Lelaps affinis Ashmead.—A paratype, U.S.N.M. no. 8087, is not the same species as the holotype but belongs instead to *Lelaps ferruginea* Ashmead.

Chalcedectes annulipes Ashmead.—Holotype from Corumba in May. Paratype from Chapada already in National Museum collection.

Macreupelmus brasiliensis Ashmead.—Only 3 of the 4 specimens mentioned by Ashmead located. U.S.N.M. type, no. 8091.

Anastatus auriceps Ashmead.—Holotype from Corumba. Paratype from Chapada missing from pin.

Trichencyrtus chapadae Ashmead (pp. 291, 392) (= *robustus* Ashmead, p. 495). See comments by Gahan and Peck, Journ. Washington Acad. Sci. **36**: 317. 1946; also Gomes, Bol. Soc. Brazil. Agronomia **5**: 287. 1942.

Metopon brasiliensis Ashmead.—The holotype female is from Corumba. The 2 paratype females are from Santarém and appear to be not the same species as the type. The allotype male, also from Santarém, is missing from the pin.

Horismenus brasiliensis Ashmead.—A specimen in the National Museum from Chapada labeled "Type No. 8094" is not the same species as the holotype, which is from Rio de Janeiro. This specimen from Chapada is not mentioned in the description and hence is neither type nor paratype.

Ametallon chapadae Ashmead.—The holotype from the Smith collection is in poor condition. The paratype which was in the National Museum and recorded in the type book under no. 8097 is missing from the pin.

Trichoporus melleus Ashmead.—The holotype acquired with the Smith collection is a female from Santarém. The alleged male described by Ashmead and bearing U.S.N.M. type, no. 8098 is a female from Chapada and is not the same species as the holotype.

Trichoporus viridicyaneus Ashmead.—All 20 specimens of the type series located, 3 of them in the National Museum under type no. 8099. These 3 are the same species as the holotype, but at least 5 of the paratypes in the Smith collection appear to be a different species.

Alophus flavus Ashmead (p. 353, 365) (=*brasiliensis* Ashmead, p. 520). See comments by Gahan and Peck, Journ. Washington Acad. Sci. **36**: 314. 1946. Holotype and allotype from Chapada and one paratype from Rio de Janeiro in Smith collection. Holotype and paratype are alike, but the allotype male is a different species. Also two alleged paratypes in the National Museum, type no. 8100, are not the same as the holotype and represent two different species.

ORNITHOLOGY.—*Continental races of the bulbul* Pycnonotus dispar (*Horsfield*).[1]

H. G. DEIGNAN, U. S. National Museum.

Geographical variation in continental populations of *Pycnonotus dispar* ("*Otocompsa flaviventris*" of the older authors) appears in a tendency to darker coloration of the upperparts, shortening of the crest, and reduced wing length from north and west to east and south. The effects of wear on the plumage are so marked that only fresh-plumaged specimens are suitable for taxonomic study, and the change from one form to another is so gradual that the distinctions between juxtaposed races can be observed only in series. The difficulty of establishing satisfactory limits of range for the several subspecies is complicated by the appearance of winter-wandering examples of one within the breeding territory of another. Two hundred and one specimens from the Asiatic mainland, brought together in Washington with the kind cooperation of the authorities of the Academy of Natural Sciences of Philadelphia (A.N.S.P.) and of the Chicago Natural History Museum (C.N.H.M.), enable me to accept the following forms:

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 16, 1948.

1. Pycnonotus dispar flaviventris (Tickell)

Vanga Flaviventris Tickell, Journ. Asiat. Soc. Bengal **2**: 573. Nov. 1833 (Dampara, "in Dholbhúm"=Singhbhum District, Chota Nagpur Division, Province of Bihar and Orissa, India).

Diagnosis.—Head and neck blue-black; upperparts *golden* olive-green, somewhat brighter posteriorly; exposed portions of remiges and rectrices blackish brown, edged with golden olive-green; underparts rich yellow, somewhat suffused with olive on the breast and along the flanks.

Wing length.—86–91 mm. (5 males), 85–89 mm. (4 females), 85–96 mm. (4 unsexed).

Specimens examined.—"INDIA": No definite locality (3 unsexed). BENGAL: Darjiling District: Sivok (1 male, 2 females). ASSAM: No definite locality (1 unsexed); Cachar District: Rupachena (1 female); Lakhimpur District: Margherita (1 male, 1 female). BURMA: Myitkyina District: N'Pon Village (1 male); Pakokku District: Dudaw Taung (2 males).

2. Pycnonotus dispar vantynei, n. subsp.

Type.—C.N.H.M. no. 79247, adult male, collected at Phongtho (lat. 22°32′ N., long. 103°20′ E.), Laokay *or* Laichau Province, northwestern Tongking, on February 24, 1929, by J. Van Tyne (original number 396).

Diagnosis.—As large as *P. d. flaviventris,* but easily separable by having the upperparts a darker and duller olive-green, almost without golden suffusion.

Wing length.—85–91 mm (20 males), 85–87 mm (4 females).

Specimens examined.—ANNAM: No definite locality (1 male); Thanhhoa Province: Hoixuan (1 female), Lunglunh (1 male). TONGKING: Laokay *or* Laichau Province: Phongtho (2 males); Laokay Province: Ba Nam Nhung (1 male); Laichau Province: Muong Mo (1 male, 2 females), Muong Moun (1 male), Paham (1 male), Laichau (1 male), 27 km WSW. of Laichau (2 males). LAOS: 5e Territoire Militaire: Bountai (3 males), Muong Yo (1 male, 1 female); Pakse Province: Pakse (1 male, *winter*). BURMA: Kengtung State: Loi Mwe (3 males, 1 female), Mong Len (1 male); SIAM: North: Chiang Saen Kao (2 females), Chiang Rai (1 male), Muang Fang (1 male), Wiang Pa Pao (1 female), Doi Suthep (2 males, *winter*); East: Ban Chanuman (1 male, *winter*).

Remarks.—Only one of these examples shows the red-throated phase of plumage (discussed below under *P. d. johnsoni*).

This race is named in honor of Josselyn Van Tyne, collector of the type specimen.

3. Pycnonotus dispar xanthops, n. subsp.

Type.—U.S.N.M. no. 332362, adult male, collected at "Khan River" = Ban Mae (lat. 18°40′ N., long, 98°50′ E.), Chiang Mai Province, northwestern Siam, on February 8, 1932, by Hugh M. Smith (original number 5321).

Diagnosis.—Smaller than either of the two precedent races and with the color of the upperparts darker, more greenish, less golden, than in *flaviventris,* but much lighter and more golden than in *vantynei.*

Wing length.—83–87 mm. (16 males), 83–85 mm. (4 females).

Specimens examined.—SIAM: Northwest: Doi Chiang Dao (1 male), Muang Pai (1 male), 30 km N. of Chiang Mai (1 male), Doi Suthep (5 males, 3 females), vicinity of Chiang Mai (3 males, 1 female), Ban Mae (2 males), Doi Khun Tan (6 males). BURMA: Amherst District Myawadi (1 male), Kawkareik (1 female).

Remarks.—This race presumably has a much more extensive range than my material shows; it should be the form of all southern Burma.

The few skins available from southwestern Siam are smaller than *xanthops;* their plumage is so badly worn that, for the present, they must be left unnamed.

4. Pycnonotus dispar auratus, n. subsp.

Type.—A.N.S.P. no. 115110, adult male, collected at Amphoe Wat Pa = Muang Lom Sak, on the borders of central and eastern Siam at lat. 16°45′ N., long 101°10′ E., on October 26, 1934, by collectors for R. Meyer de Schauensee (original number 1705).

Diagnosis.—Smaller than either *vantynei* or *flaviventris* and with the color of the upperparts lighter, less greenish, more golden, than in the former, but much darker and less golden than in the latter.

From *P. d. xanthops,* with which it agrees in size, *auratus* is separable by having the upper parts slightly darker and less golden.

Wing length.—85–87 mm (4 males), 82–84 mm (5 females).

Specimens examined.—LAOS: Vientiane Province: Vientiane (1 female). SIAM: Central *or* East: Muang Lom Sak (4 males, 5 females). ANNAM: Phanrang Province: Krongpha (1 female, *winter*).

Remarks.—*P. d. auratus* and *P. d. xanthops* are equivalent "links" in the cline between *flaviventris* and *vantynei.* The range of *auratus*

may be expected to cover the more eastern provinces of northern Siam, the northern half of the eastern Siamese plateau, and portions of Haut- and Moyen-Laos between the territories of *vantynei* and *johnsoni*.

One of my specimens shows the red-throated phase of plumage; another has an irregular spot of red and yellow feathers at the left side of the chin.

5. **Pycnonotus dispar johnsoni** (Gyldenstolpe)

Rubigula johnsoni Gyldenstolpe, Kungl. Svenska Vet.-Akad. Handl. **50** (8): p. 25, col. pl. 1. July 19, 1913 (near Sathani Chakkrarat, Nakhon Ratchasima Province, eastern Siam at lat. 15°00′ N., long. 102°25′ E.).

Diagnosis.—Near to *P. d. auratus*, but smaller and with the upperparts slightly darker and less suffused with golden.

Wing length.—79–85 mm (33 males), 76–83 mm (34 females), 81–83 mm (3 unsexed).

Specimens examined.—SIAM: East: Sathani Pak Chong (7 males, 9 females), Sathani Hin Lap (3 males), Sathani Lat Bua Khao (5 males, 3 females), Ban Tha Chang (1 unsexed), Ban Khanong Phra (2 females), Ban Pang Sok (1 male), Nakhon Nayok (1 unsexed), Ban Chanuman (4 females), Ban Khulu (1 unsexed), Ban Khemmarat (1 female); Southeast: Khao Saming (2 males, 1 female), Ban Bang Phra (1 male, 1 female), Ban Laem Ngop (1 male), Khao Sa Bap (3 males, 1 female), Khao Soi Dao (1 male), Muang Rayong (2 females), Siracha (1 male), Ban Nong Kho (3 males), Ban Nong Yang (4 males); LAOS: Pakse Province: Pakse (2 males, 4 females), Paksong (1 female, 1 unsexed), Bassac (1 female). CAMBODIA: Kampot Province: Ok Yam (1 female); Siemreap Province: Banteai Srei (1 female); Kompong Cham Province: Kompong Cham (1 female). ANNAM: Phanrang Province: Krongpha (1 female, 1 unsexed), between Bellevue and Daban (1 male, 3 females), Fimnon (1 female), Ban Methuot (1 male).

Remarks.—A color phase in which the lower throat is clothed in shining red feathers is frequent in *johnsoni;* in the population of the southwestern corner of the eastern Siamese plateau (topotypical), all the specimens seen show the character, which appears with diminishing frequency as one moves away from this center and is then often indicated merely by a few red feathers among the black. Since red-throated individuals appear in any predominantly black-throated population of southeastern Indo-China (and even in populations otherwise representative of the races *auratus* and *vantynei*), it is not possible to restrict the use of Gyldenstolpe's name to red-throated birds without seeming to have two subspecies resident at the same localities, and there is, of course, no question here of two sympatric species. A case precisely similar to this is presented by the bulbul *Pycnonotus atriceps* (Temminck), in which the several color phases appear with varying frequencies from one to another part of the ranges of the different races.

The problem has been discussed at some length by R. Meyer de Schauensee (Proc. Acad. Nat. Sci. Philadelphia **98**: 53–56. 1946), whose conclusions, however, do not wholly agree with mine.

6. **Pycnonotus dispar caecilii,** n. subsp.

Type.—U.S.N.M. no. 160418, adult male, collected in Trang Province, peninsular Siam at *ca.* lat. 7°–8° N., on February 12, 1897, by William L. Abbott.

Diagnosis.—Nearest *P. d. johnsoni* (black-throated phase), but with the upperparts a decidedly darker olive green, almost without golden suffusion.

Wing length.—78–82 mm (10 peninsular males), 78–81 mm (6 peninsular females).

Specimens examined.—SIAM: Southeast: Ko Kut (3 males, 1 female, 1 unsexed), Ko Chang (8 males, 1 female, 1 unsexed); Southwest: Prachuap Khiri Khan (1 female), Khao Luang (1 male, 2 females), Khao Nok Wua (1 male, 1 female); Peninsula: Ban Tha Lo (1 female), Nakhon Si Thammarat (1 male), Khao Phanom Bencha (3 males, 1 female), Trang Province (4 males, 2 females). BURMA: Mergui District: Victoria Point (1 male). MALAYA: Selangor State: Ginting Bidei (1 male).

Remarks.—This race was named *Otocompsa flaviventris minor* by Boden Kloss (Ibis, ser. 10, **6** (2): 200. Apr. 9, 1918), with the type specimen from Ko Lak = Prachuap Khiri Khan. With the submersion of "*Otocompsa*" in *Pycnonotus*, Kloss's name becomes preoccupied by *Pycononotus nigricans* Var. *minor* von Heuglin (Ornithologie Nordost-Afrika's **1**: 398. 1869), and a new designation is required for the bird of the Malay Peninsula.

Kloss's type lies before me and seems to be inseparable from more southern specimens.

Nevertheless, since Prachuap Khiri Khan is situated just where numerous peninsular races intergrade with distinct forms of southwestern Siam, it has seemed to me desirable to fix the new name on a much more southern population, rather than simply to rename Kloss's bird. The word "*caecilii*" derives, of course, from this earlier worker's given name.

That the 15 specimens from Ko Kut and Ko Chang should be quite distinct from birds of the neighboring mainland, but virtually inseparable from those of the Malay Peninsula, is of considerable interest. Their wing length ranges from 81 to 85 mm (11 males), 80 to 83 mm (2 females); they are thus a trifle larger than topotypical *caecilii*, but hardly enough to justify their separation at this time. One example has a few red feathers on the lower throat.

ICHTHYOLOGY.—Acanthurus triostegus marquesensis, *a new subspecies of surgeonfish, family Acanthuridae, with notes on related forms.*[1] LEONARD P. SCHULTZ and LOREN P. WOODS.

During our studies of tropical Pacific Ocean fishes, we observed that in the vast area from the East African coast to the western shores of the Americas certain species said by certain ichthyologists to be the same throughout this entire region are actually separate species, subspecies, or distinct populations. Among these, the surgeonfish, *Acanthurus triostegus* (Linnaeus), is one of the most abundant and widely distributed species of the Indo-Pacific region. It ranges from the Red Sea and Natal coast of South Africa eastward to Australia and thence in Oceania to the offshore American islands—Clarion, Clipperton, and Cocos. In the Hawaiian chain of islands this surgeonfish is represented by a distinct species, *Acanthurus sandvicensis* Streets, and by some means it has extended its range to include Johnston Island, 520 miles southward.

In order to clarify the status of the various species and subspecies of surgeonfishes closely related to *A. triostegus* we studied specimens from the Pacific and Indian Oceans and found that certain of the larger island groups of the Pacific have populations of this surgeonfish morphologically distinct from other island groups. Therefore, we find it necessary to describe as new a subspecies from the Marquesas and to point out other distinct populations without naming them at this time.

Throughout the entire range of this surgeonfish the five narrow dark bars on the sides show no significant variability. The first body band ends in the axil of the pectoral base. In contrast the dark bar on caudal peduncle varies greatly from a dorsally located spot to one completely encircling the peduncle. Usually it is in the form of a dorsal saddle with a spot ventrally disconnected from the saddlelike dark mark.

The larval stages of this surgeonfish are unknown to us, but numerous examples of postlarvae occur in the U. S. National Museum collections. All have been taken over reefs or near land; those from 21 to 25 mm in length have been collected from tidal pools. The smallest specimen seen by us was 20.5 mm. It was colorless when it appeared at a light at night. This suggests a pelagic habitat for the young.

Acanthurus sandvicensis Streets

Acanthurus triostegus sandvicensis Streets, U. S. Nat. Mus. Bull. **7**: 67. 1877. (Type locality, Honolulu Harbor, Oahu, T. H.) Lectotype, U.S.N.M. no. 15398, and paratypes, U.S.N.M. no. 143446.

Acanthurus sandvicensis Streets is characterized by having a black streak running from the upperpart of the pectoral base to near the ventral surface (see Fig. 1, A), and by averaging one or two more soft rays in the dorsal, anal, and pectoral fins. (See Table 1.) The streak below the pectoral was found in all specimens examined (about 100) from the Hawaiian and Johnston Islands and in no specimen from any other locality.

The distinct character of the color pattern of *Acanthurus sandvicensis* and its complete lack of intergradation with representatives of *trio-*

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received March 23, 1948.

stegus from other island groups reemphasize the recognized long-time isolation of the Hawaiian Chain. The average temperature of the water around the Hawaiian Islands and Johnston Island is a little lower than the average for most parts of the equatorial western Pacific Ocean. This may have caused the meristic differences recorded for *sandvicensis*, but it does not explain the difference in color pattern.

Acanthurus triostegus triostegus (Linnaeus)

Chaetodon triostegus Linnaeus, Systema naturae, ed. 10: 274. 1758. (Type locality, Indies.)

The normal color pattern of alcoholic specimens is a light-gray to dark-brown background on head and body with the dorsal parts darker, and ventral region whitish; middorsal line of interorbital space and of snout usually with a brown streak; head and body with 5 narrow transverse brownish or blackish bars, the first from nape through eye across cheek to lower margin of preopercle, the second from dorsal origin to base of pectoral, the third from below fifth dorsal spine nearly to anus, the fourth from base of second dorsal soft ray to first soft anal ray, and the fifth from about the seventh to ninth dorsal rays to below the eighth soft anal ray; caudal peduncle usually with a narrow black saddle across dorsal surface extending down to about middle of sides, lower part of caudal peduncle usually with a small spot or short dash (sometimes the dorsal saddle is connected with this spot but this character has been found to be too variable to consider here); median fins dusky, the anal with a narrow white margin; pectoral fin translucent.

The normal or typical color mark on the upper part of pectoral fin base (Fig. 1, B) consists of a single dark spot.

Specimens in breeding colors have a distinct lengthwise line along lower sides, below this, body abruptly white, anal fin black basally, often with a broad white margin; the transverse lines on females apparently narrower than those of males.

Variability among island groups.—The specific marks that show consistent variability along certain lines center around the pectoral fin base, such as (1) a dark spot below pectoral fin base, or (2) the elongation of the usual round dark spot into a short bar. These changes usually occur along with an increase of about one additional ray in the dorsal, anal, or pectoral fins.

Among the specimens from the Indian Ocean and western Pacific—Marianas, Marshall, and Samoan Island groups—only an occasional specimen differed from the normal color pattern of *triostegus*. Four out of five specimens from Tahiti had one more pectoral fin ray on both sides, but no color variations. One specimen each available from the isolated Baker, Christmas, and Fanning Islands were normal *triostegus*.

In one-third of the Phoenix Island specimens there occurred either an extra spot, a bar (Fig. 1, D), or an elongate spot (Fig. 1, E), and about one-third had one more pectoral fin ray than the average for *triostegus*. This may indicate a variation in the direction of *sandvicensis*.

Of the six small specimens examined from the Tuamotus, four had a bar across the pectoral base (Fig. 1, D) and two had one spot, and one specimen had an additional pectoral fin ray.

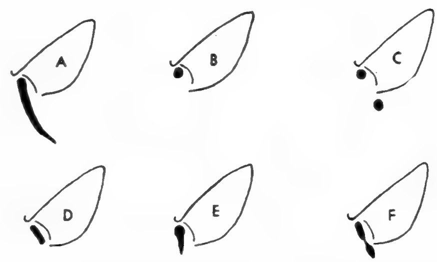


FIG. 1.—Diagram showing different color patterns on base of pectoral fin: A, *Acanthurus sandvicensis;* B, normal *A. triostegus;* C, *A. triostegus marquesensis* (adult); D, bar; E, elongate spot (Phoenix Islands); F, elongate spot (in juvenile *marquesensis*).

No notable difference in color pattern was observed for examples from the American offshore islands of Clarion, Clipperton, and Cocos, but half of them have an extra ray in the pectoral fin. Jordan and Evermann (Bull. U. S. Bur. Fish. **23** (1): 395. 1905) state: "To the Hawaiian species, *Hepatus sandvicensis*, belong the specimens recorded by Jordan and Evermann (U. S. Nat. Mus. Bull. 47, pt. 2: 1690. 1898), from Clarion and Socorro Islands." Our 11 specimens from Clarion have a single spot on the pectoral base with no indication of the extension or streak below the pectoral characteristic of *sandvicensis*. Heller and Snodgrass (Proc. Washington Acad. Sci. **6**: 403. 1900) list 37 specimens from Cocos Island and say: "All of the Revillagigedo and Cocos specimens differ from Hawaiian specimens of the very closely related *Hepatus sandvicensis*

(Streets) in lacking the black band reaching from the base of the pectoral to the base of the ventral. There is a dark spot on the outer side of the base of the pectoral and in some a similar spot below this one." This is in harmony with our findings.

Acanthurus triostegus is one of the few tropical Indo-Pacific species that crosses the East Pacific Barrier (Ekman, 1935, pp. 105–107). One would suppose this Eastern Pacific-American area to be more isolated than any of the Central Pacific island groups, yet we can detect no significant variation.

Acanthurus triostegus marquesensis, n. subsp.

Hepatus triostegus Fowler, Proc. U. S. Nat. Mus. **80**: 10. 1932.

Holotype.—U.S.N.M. no. 89771, Marquesas Islands, Ua Huka, September 24, 1929, Gifford Pinchot, 84.3 mm.

Paratypes.—U.S.N.M. no. 143447, same data as holotypes, 13 specimens, 49 to 86 mm; C.N.H.M. nos. 23065, 23066, Marquesas Islands, Nuka Hiva Island, February 7, 1929, Crane Pacific Expedition, 2 specimens, 31 and 38 mm; C.N.H.M., nos. 23062, 23063, 23064, Marquesas Islands, Hiva Oa Island, February 6, 1929, Crane Pacific Expedition, 3 specimens, 25.7 to 28.5 mm.

Description.—(The counts and measurements of the holotype are given first, the range of variation of paratypes in parentheses, measurements expressed in thousandths of the standard length.) Dorsal rays IX, 24 (IX, 22 to 24); anal rays III, 21 (III, 19 to 21); pectoral rays I, i, 14 (13 or 14); pelvic rays I, 5 (I, 5); branched caudal rays upper lobe 7, lower lobe 7; teeth on one side of jaws, upper 7 (7), lower 8 (7 or 8).

Depth of body 529 (510 to 605); length of head (tip of snout to upper edge of gill opening) 312 (315 to 331); length of snout 193 (176 to 198); diameter of eye 93 (93 to 136); least depth of caudal peduncle 109 (110 to 127); length of pectoral fin 173 (268 to 321); postorbital part of head (hind margin of eye to upper edge of gill opening) 54 (51 to 78); lower lobe of caudal fin 284 (268 to 315), upper lobe 285 (277 to 333); interorbital width 91 (94 to 125); length of caudal spine 32 (29 to 47; angle of snout profile 57 (54 to 56); snout profile slightly concave convex in young; caudal fin slightly forked.

Color.—In alcohol, head and body dark brown, with five transverse narrow dark lines, the first from nape through eye to lower margin of preopercle, the second from origin of spiny dorsal to axil of pectoral fin, the remaining three as described for *triostegus*; dark line form-

TABLE 1.—COUNTS AND COLOR CHARACTERISTICS RECORDED FOR ACANTHURUS TRIOSTEGUS AND A. SANDVICENSIS

Species and Locality	Dorsal rays								Anal rays						Pectoral rays			Coloration of pectoral base			
	VIII	IX	X	21	22	23	24	25	III	18	19	20	21	22	I, i, 12	I, i, 13	I, i, 14	One spot	Bar	Two spots	Streaks
Acanthurus triostegus triostegus:																					
Indian Ocean, Mauritius; Seychelles	—	11	1	—	6	5	1	—	12	1	1	7	3	—	—	12	—	10		2	
Sumatra; New Guinea; Solomons; Philippines	—	10	—	1	3	6	—	—	10	—	3	6	1	—	2	8	—	10			
Okinawa; Japan	—	7	—	—	2	4	1	—	7	—	3	3	1	—	—	7	—	5	1	1	
Guam; Marshalls	—	21	—	—	7	13	—	1	21	—	2	17	1	1	—	17	4	21			
Niuafu; Samoa	—	8	—	—	3	4	1	—	8	—	—	5	3	—	—	6	2	7		1	
Phoenix Islands	—	11	—	—	1	8	2	—	11	—	—	7	4	—		10	6	30	10	3	
Tahiti	1	3	—	—	1	2	1	—	4	—	1	2	1	—		2	6	4			
Tuamotus; Mangareva; Takaroa	—	6	—		1	5	—	—	6	—	—	4	2	—	1	11	2	2	4		
Eastern Pacific, Clarion, Clipperton; Cocos Islands	—	14	—	2	2	9	1	—	14	—	2	6	5	—		7	7	14			
Acanthurus triostegus marquesensis:																					
Marquesas	—	14	—		2	10	2	—	14	—	1	6	7	—		10	24		4	15	
Acanthurus sandvicensis:																					
Hawaiian and Johnston Islands	—	32	—		1	13	16	2	32	—	1	5	24	2	—	5	27				32

ing saddle over dorsal surface of caudal peduncle extending down sides of caudal peduncle and joining with spot on lower side on one side, lower spot separate on other side (these are joined on at least one side in 5 paratypes, separate on both sides in 17); holotype and paratypes 49 to 86 mm, with a large distinct spot below the pectoral fin base (Fig. 1, C); young specimens 25.7 mm have a faint dark bar about twice as long as diameter of pectoral base, narrowing and fading ventrally but not as long as in *A. sandvicensis;* in the 31-mm specimen the pectoral spot is conspicuous and in the form of an elongate bar, pinched in the middle and tapering ventrally; on one 38-mm example the bar has completely divided into a short bar across the base of pectoral in one side and lower half is more or less rounded into a spot as those of 49 to 86 mm, but on the other side the division into two parts is not quite complete (Fig. 1, F). A distinct spot on pectoral fin base; a small faint spot near lower edge of gill opening, and 3 faint spots in line along side of breast, median fins dark, the anal with a narrow white border; pelvics dark, their outer margin and tips pale.

Remarks.—On all the Marquesas Islands specimens occurs a large dark spot below the pectoral fin base except in very small specimens as described above in addition to the usual spot on the pectoral base. Only occasional specimens of *A. triostegus triostegus* from other parts of the Pacific and Indian Oceans have this additional spot. In the Marquesas Islands this extra spot occurs along with a consistently higher average number of anal and pectoral fin rays, thus separating the new subspecies from *A. triostegus triostegus.* Named *marquesensis* after the island group where this subspecies occurs.

ZOOLOGY.—*The tardigrade fauna of the District of Columbia.*[1] CHARLES B. CURTIN,[2] Catholic University of America. (Communicated by E. G. REINHARD.)

The Tardigrada constitute a group of microscopic animals usually included, as a class, in the phylum Arthropoda. All are hygrophilous, but some species are restricted to marine and fresh-water habitats. Their distribution is world-wide, the number of species being greater in the sub-Arctic than in the tropical regions. No reference to a study of the Tardigrada of the District of Columbia was found in the literature, but Marcus (1929, p. 576) and Mathews (1938, pp. 624–626) listed one species, *Macrobiotus hufelandii* C. Schultze, as an inhabitant of this area. The results of a survey conducted by the writer in this region are contained in this paper.

Packard (1873, p. 740) was the first to note the presence of a tardigrade in the United States, but his description is unfortunately inadequate. A tardigrade from New Gloucester, Maine, was described by Beal (1880, p. 593). The species, however, can not be determined with accuracy. Mathews (1938, p. 625) stated that it fits the description of *Hypsibius augusti* Murray. To date, 14 species of Tardigrada have been reported for the United States. Of this number, two, *Batillipes mirus* Richters and *Bathyechiniscus tetronyx* Steiner, are marine species. The two described by Packard and Beal are incertae sedis. None of the species reported for the United States are peculiar to this country as they have been previously noted as inhabitants of other countries.

Terrestrial Tardigrada inhabit lichens and mosses while aquatic species may be found on water plants. Richters (1927, pp. 1–3) noted that the tropical mosses were poor both in species and number. In his survey, Murray (1907, p. 515, and 1913, p. 136) listed 25 species of Tardigrada from South Africa. The exact localities of the collections were not given, but from the regional topography the average elevation was 4,000 feet. Teunissen (1938, pp. 6–15) listed 1,200 meters as the lowest elevation

[1] A contribution from the Department of Biology, the Catholic University of America, Washington, D. C. This paper, prepared under the direction of Dr. E. G. Reinhard, is based on the author's dissertation submitted in partial fulfillment of the requirements for the degree master of science. Received January 16, 1948.

[2] Now biology instructor at Mount St. Mary's College, Emmitsburg, Md.

TABLE 1.—LIST OF TARDIGRADA REPORTED FROM THE UNITED STATES
(compiled from papers of Marcus, Mathews, and Packard)

Species	Locality	Authority
1. *Batillipes mirus* Richters (*B. caudatus* Hay)	Beaufort, N. C.	W. P. Hay
2. *Bathyechiniscus tetronyx* G. Steiner	California coast	Mathews
3. *Echiniscus arctomys* Ehrenberg	Brandon, Vt.; East Troy, Wis.	Mathews
4. *Echiniscus merokensis* Richters	San Juan Island and Longmires Springs, Wash.	Mathews
5. *Pseudechiniscus suillus* Ehrenberg	Brandon, Vt.; Catalina Island, Calif.	Mathews
6. *Macrobiotus hufelandii* C. Schultze	Ephraim and East Troy, Wis.; Washington, D. C.; Isle Royal, Mich.; San Juan Island, Wash.	Mathews Marcus Mathews
7. *Hypsibius schaudinni* Richters	Galveston, Tex.	Mathews
8. *Hypsibius prosostomus* Thulin	Isle Royal, Mich.	Mathews
9. *Hypsibius canadensis* Murray	Catalina Island, Calif.	Mathews
10. *Hypsibius convergens* Urbanpwicz	Niagara Falls, N. Y.	Marcus
11. *Hypsibius oberhäuseri* Doyère	East Troy, Wis.; Catalina Island, Calif.	Mathews
12. *Milnesium tardigradum* (Schrank)	East Troy Wis.; Techny, Ill.; Friday Harbor and San Juan Island, Wash.	Neuhaus Mathews
SPECIES INCERTAE SEDIS		
13. *Hypsibius augusti* Murray	New Gloucester, Maine	Beal
14. *Hypsibius americanus* Packard	New Gloucester, Maine	Packard

at which he found Tardigrada. These elevations approximated those of the subalpine region, and environmental conditions would favor the support of a tardigrade fauna. Despite the unfavorable physiography of the District of Columbia, foliose lichens and water samples collected from the Rock Creek Park, Fort Dupont Park, and the Catholic University campus yielded 39 specimens. Two were aquatic and 37 were terrestrial forms. These represented three definite species and two of uncertain nature. Table 2 lists the species and location where the Tardigrada were obtained.

Macrobiotus hufelandii C. Schultze

1834. *Macrobiotus hufelandii* Schultze, Macrobiotus Hufelandii, animal e crustaceorum classe novum reviviscendi post diuturnam asphyxiam et ariditatem potens . . . Berolini.
1895. *Macrobiotus eminens* Ehrenberg, Abh. Adad. Wiss. Berlin, 1858: 452, pl. 2, fig. 1, A–E.
1914. *Macrobiotus interruptus* Della Valle, Ann. Mus. Zool. Napoli, Suppl. 1, no. 7: 29.

Twenty-one specimens of this species were obtained. The average length of the larger specimens was 500μ. The eyespots were black and prominent. The cuticle of the live animals appeared annulated with wide bands of gray-white color separated by a thin, clear constricted area. Typical claws present with basal lunulae. Lamellae surrounded the mouth. The pharynx was ovoid with distinct commas. The anterior macroplacoid touched the apophyses.

Milnesium tardigradum (Schrank)

Fig. 2

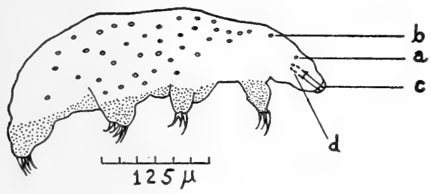
1803. *Arctiscon tardigradum ?* Schrank, Fauna Boica **3** (1): 195.
1840. *Milnesium tardigradum* Doyère, Ann. Sci. Nat., Zool. ser. 2, **14:** 283.
1859. *Acrophanes schlagintweitii* Ehrenberg, Abh. Akad. Wiss. Berlin, 1858: 451, pl. 1, fig. 1, A–F.

Fifteen specimens were obtained which were well pigmented and of the characteristic orange-brown color. The largest was 416μ long. The eye spots were large and black. The cephalic palps were prominent and the wide, short buccal

TABLE 2.—TARDIGRADA FOUND IN THE DISTRICT OF COLUMBIA

Species	Locality
1. *Macrobiotus hufelandii* C. Schultze	Rock Creek Park
2. *Milnesium tardigradum* (Schrank)	Rock Creek Park
3. *Hypsibius dujardini* (Doyère)	Catholic University Campus
4. *Hypsibius* sp.	Catholic University Campus
5. *Hypsibius* sp.	Fort Dupont Park

tube emptied into a saclike pharynx lacking placoids. The claws were united at the base by a cuticular band.



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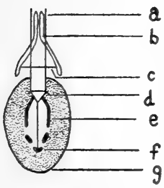

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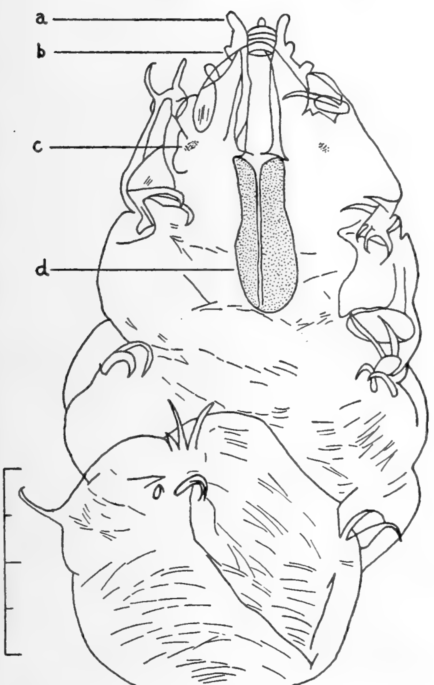

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FIG. 1.—*Macrobiotus hufelandii*, lateral view: *a*, eyespot; *b*, cuticular depression or pearl; *c*, peribuccal lamellae; *d*, macroplacoids. FIG. 1a.—Pharynx of *M. hufelandii*: *a*, buccal tube; *b*, stylet; *c*, tooth bearer; *d*, apophysis; *e*, macroplacoid; *f*, microplacoid or comma; *g*, pharyngeal bulb.

FIG. 2.—*Milnesium tardigradum*, ventral view: *a*, external palp; *b*, lateral palp; *c*, eye spot; *d*, pharynx.

Hypsibius dujardini (Doyère)

Fig. 3, 3a

1840. *Macrobiotus dujardin* Doyère, Ann. Sci. Nat., Zool., ser. 2, **14:** 288.
1851. *Macrobiotus lacustris* Dujardin, Ann. Sci. Nat., Zool., ser. 3, **15:** 164.
1911. *Hypsibius dujardini* Thulin, Arkiv Zool. **7** (16): 33.

Of this small, transparent, aquatic form, only a single specimen was obtained. It measured 177μ. The eyespots were black and the claws dissimilar, the basal part being short. In the short straight buccal tube, the anterior macroplacoid was longer than the posterior. The cuticle appeared to be a faint gray-green color in the abdominal region.

Hypsibius species

Fig. 4

The identification is based upon a molt which contained four ovoid eggs. These measured 22μ by 39μ. The length of the animal was 162μ. The claws were partially concealed but appeared to be the *Hypsibius* type. The cuticle showed some spiny protuberances leading to the belief it might be *Hypsibius ornatus* Richters.

Hypsibius species

Fig. 5

This identification is assigned to a skin with 13 eggs obtained in a water sample. The eggs were slightly ovoid measuring 48μ by 61μ. The molt measured 168μ. The claws appeared to be of the *Hypsibius* type and it approximated the description of *Hypsibius dujardini* (Doyère). It appeared very probable that it was the molt of this species.

Thirty-nine specimens of Tardigrada were obtained in the survey, and duplicates have been deposited in the United States National Museum. Three distinct species and two of a dubious nature were represented. Mosses were found to be poor habitations for Tardigrada, while foliose lichens in the Rock Creek Park area yielded the best results. Of the 10 good terrestrial and aquatic species reported for the United States, two, *Macrobiotus hufelandii* C. Schultze and *Milnesium tardigradum* (Schrank) are inhabitants of the District of Columbia. The range of *Milnesium tardigradum* (Schrank) can now be extended to include this region. The presence of *Hypsibius dujardini* (Doyère) is the first reported occurrence of this species for the United States. The possibility of one

molt being *Hypsibius ornatus* Richters would add another species to the list of those that inhabit the United States. All specimens were found to be smaller than the average of those reported from colder regions.

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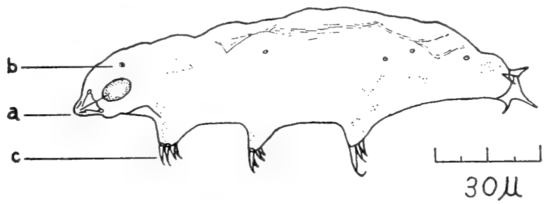

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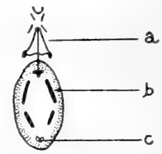

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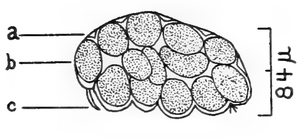

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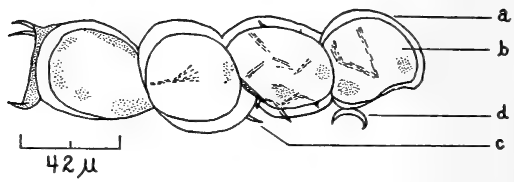

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Fig. 3.—*Hypsibius dujardini*, lateral view: *a*, mouth; *b*, eyespot; *c*, claws.
Fig. 3a.—Pharynx of *H. dujardini:* *a*, stylet; *b*, macroplacoid; *c*, microplacoid.
Fig. 4.—*Hypsibius* species. Molt containing 13 eggs: *a*, the cuticle; *b*, an egg; c, a claw.
Fig. 5.—*Hypsibius* species. Molt containing 4 eggs: *a*, the cuticle; *b*, an egg; *c*, a spine; *d*, a claw.

PROCEEDINGS OF THE ACADEMY

418th Meeting of Board of Managers

The 418th meeting of the Board of Managers held in the Cosmos Club, May 17, 1948, was called to order at 8:05 p.m. by the President, Dr. F. D. Rossini. Others present were: H. S. Rappleye, N. R. Smith, J. I. Hoffman, F. G. Brickwedde, W. N. Fenton, W. Ramberg, T. D. Stewart, J. W. Aldrich, C. E. White, W. W. Rubey, W. A. Dayton, C. A. Betts, M. A. Mason, A. O. Foster, C. L. Gazin, and, by invitation, H. E. McComb, F. C. Kracek, L. V. Judson, and F. Thone.

The Chairman of the Committee on Membership, H. E. McComb, presented 27 nominations for resident membership.

The Chairman of the Committee on Monographs, Dr. L. V. Judson, reported the committee's favorable reaction to Dr. Herbert Friedmann's monograph on *The parasitic birds of Africa.* Upon a motion by Dr. Judson, the Board voted to accept the bid of the Lord Baltimore Press to publish, in buckram binding, 1,000 copies of the monograph at a cost to the Academy of approximately $2,100. It was agreed that the map of North Africa recom-

mended to Dr. Friedmann should be included, raising the printing cost about $30. Dr. Judson recommended that the price the Academy is to charge for copies of the monograph be fixed so that the cost of publication is returned in the sale of half of the edition.

Dr. Frank Thone, the Academy representative on the Joint Committee on Press Relations, presented a report on the financial standing of the committee which the Board voted to refer to the Executive Committee for consideration and recomendation.

The Chairman of the committee appointed to consider and make recommendations regarding an index to the Journal, Dr. W. N. Fenton, presented a report which was also referred to the Executive Committee for consideration and recommendation.

The Secretary reported the result of the ballot submitted to the membership regarding the change in the Bylaws proposed at the 417th meeting of the Board: 1. Amendment to create office of President-elect (Yes, 254; No. 10). 2. Amendment to increase permitted number of active members (Yes, 251; No. 13). Total ballots cast, 264.

The Secretary announced the death of Albert Fred Woods, an original member, on April 12, 1948.

The Board approved the following changes in the Standing Rules proposed at the 417th meeting:

Section 3, third sentence, replace by—

"The Committee on Membership, Meetings, Grants-in-Aid for Research, and each of the Subcommittees of the Committee on Awards for Scientific Achievement shall include, if possible, at least two members reappointed from the preceding year. The Committee on Monographs shall have six members, each appointed for three years at the rate of two each year. At least three members of the Committee on Monographs shall be past editors of the Journal, if possible."

New Section S, second sentence, replace by—

"A candidate must be a member of the Washington Academy of Sciences or a resident member of one of the Affiliated Societies and shall not have passed the 40th anniversary, etc. . . . "

The meeting was adjourned at 10:40 p.m.

C. L. Gazin, *Secretary*

THE 1947 ACADEMY AWARDS FOR SCIENTIFIC ACHIEVEMENT

As encouragement to younger scientists the Washington Academy of Sciences makes three annual Awards for Scientific Achievement to members of the Academy or resident members of the affiliated societies—one in the Biological Sciences, one in the Engineering Sciences, and one in the Physical Sciences.

Only two awards were made for 1947. The winners were Robert DeWitt Huntoon, of the National Bureau of Standards, in the Physical Sciences; and Harry Warren Wells, of the Carnegie Institution of Washington, in the Engineering Sciences. The awards were made at the regular meeting of the Academy at the Cosmos Club on the evening of March 18, 1948. Dr. Huntoon's citation was "in recognition of his distinguished service in the advancement of electronics and its applications to other sciences and to modern ordnance." Mr. Wells's was "in recognition of his distinguished upper-air research and organization of a world-wide network of ionospheric stations."

Robert DeWitt Huntoon

Dr. Huntoon was born at Waterloo, Iowa, on July 20, 1909. After obtaining his B.A. degree from Iowa State Teachers College in 1932, he began graduate work at the State University of Iowa, receiving his M.S. degree in 1935 and his Ph.D. in 1938. During this time he also served as graduate teaching assistant (1933–35) and research assistant in the University's department of physics (1935–38). Leaving Iowa, he became instructor in physics at New York University (1938–40), then research physicist with the Hygrade Sylvania Corporation (Sylvania Electric Products, Inc.) at Emporium, Pa. (1940–41), and in 1941 joined the staff of the National Bureau of Standards to work on electronic ordnance devices. In 1944–45 he served as expert consultant to the Office of the Secretary of War, but

returned to the Bureau to become chief of the Basic Research Section, Ordnance Development Division, and later chief of the Electronics Section. At present he is assistant chief of the Atomic Physics Division.

Robert DeWitt Huntoon

In addition to the Academy Award, Dr. Huntoon is the recipient of two other distinguished recognitions of his abilities: A Naval Ordnance Development Award and a War Department Certificate of Appreciation, both in 1946. He is a member of the American Physical Society, the Philosophical Society of Washington, the Institute of Radio Engineers (senior member), Sigma Xi, and Kappa Delta Pi.

Harry Warren Wells

Mr. Wells is a native of Washington, D. C., where he was born on January 13, 1907. He received the B.S. degree in electrical engineering in 1928 and the E.E. degree in 1937 from the University of Maryland. Between 1928 and 1932 he was associated with the Westinghouse Electric & Manufacturing Co., the All-American Malaysian Expedition to Borneo, Heintz & Kaufman, Ltd., and the Army Air Forces. He has been a member of the scientific staff of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, since 1932. His investigations, both here and abroad, have contributed materially to knowledge of the ionosphere, radio wave propagation, and related geophysical subjects.

Mr. Wells is a member of the Committee on Wave Propagation and Utilization of the

Harry Warren Wells

Institute of Radio Engineers and is a senior member of that Institute. His other professional affiliations include the Washington Academy of Sciences, the American Geophysical Union, and the Philosophical Society of Washington.

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JOURNAL
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VOL. 38 AUGUST 15, 1948 No. 8

ETHNOLOGY.—*Utilization of marine life by the Wampanoag Indians of Massachusetts.*[1] FRANK G. SPECK, University of Pennsylvania, and RALPH W. DEXTER, Kent State University. (Communicated by WILLIAM N. FENTON.)

Coastal Indians have always possessed a unique advantage. Marine resources have been at their disposal for use in many ways, especially for food. Undoubtedly marine foods played the most important part in the diet of these aboriginals as indicated by numerous prehistoric shell heaps, and also by the persistence to the present day of the use of marine animals by the living descendants of the shell-heap builders. The writers have made a study of the use of marine life, with special reference to the marine invertebrates, by the Wampanoag Indians living at Mashpee on Cape Cod and at Gay Head on Marthas Vineyard. Information obtained from informants[2] portrays the use of marine life from about 1850 to the present. This is correlated with published records on the contents of shell heaps which have been excavated in the region.

A preliminary survey was made at Mashpee and Gay Head in August 1940. In 1946 a concentrated study was made in the Mashpee area (including Herring Pond). In 1947 a brief revisit to this area and a concentrated study with the Gay Head group was undertaken. Table 1 summarizes the marine life known to have been used by the Wampanoag, and compares marine forms cited by living Indians with marine life collected in the vicinity and with remains recovered from local shell heaps.

Byers and Johnson (1940) characterize the Wampanoag as "a rather undeveloped fishing and hunting people" and say that "shellfish were the principal part of their diet." Earlier, Chase (1885) stated that they were "largely dependent for food upon the fish and shellfish which they caught at the mouth of streams and sheltered bays." In reporting an early journey of Edward Winslow and Stephen Hopkins with Squanto from Plymouth to Narragansett Bay, Miller (1880) described the travelers meeting Indians "with baskets of roasted crab fishes and other dried shell fish." They also encountered Indians fishing for bass at a weir on the Taunton River, and "at Mattapoiset they ate oysters and other fish." Miller also pointed out that "as soon as the shores were clear of snow and ice, in the spring, they would naturally flock to them, for shellfish, and watch for the coming of the early sea fish." The abundant shell heaps of coastal Massachusetts leave no doubts as to the importance of marine life, especially the mollusks, in the economy of the aboriginals. There is also evidence that the Indians of the interior journeyed to the coast to obtain shellfish, which were smoked or dried for winter use.

The salt-water ponds, inlets, and bays along the shore have provided sea foods for these people for many centuries. Squibnocket Pond at Marthas Vineyard is no longer connected with the sea, but Guernsey (1916) presented evidence that the Indians

[1] Received April 20, 1948. To the Faculty Research Fund (Grant no. 594), University of Pennsylvania, the senior author is indebted for financial support of this Wampanoag Ethnological project.

[2] We are grateful to the following informants: From the Mashpee group: Mr. and Mrs. William Sturgis, Marshall Jeffers, Edward Amos, Fred Gardner, Mr. and Mrs. Ambrose Pells, and Clinton Haynes. From the Herring Pond group: Mrs. Josephine Webquish, Mrs. Ella Hirsh Grover, and Howard Hirsh. From the Gay Head group: Linus Jeffers, Mr. and Mrs. William Ryan, Harry Vanderhoop, Mr. and Mrs. Jerry Diamond, Grover Ryan, and Eva Ryan.

had opened it to the sea with a channel way for the purpose of introducing marine fish and shellfish. Such ponds as Menemsha Pond and Tisbury Pond still furnish them with food. In August 1947, the junior writer accompanied Linus Jeffers of the Gay Head band on a trip into Menemsha Pond for the collection of shellfish, and notes were taken on the marine life available there for comparison with archeological records and recent ethnological information on the use of such marine organisms in past and recent times by the inhabitants of Gay Head. Fresh-water ponds such as Mashpee Pond, and Herring Pond have long provided an abundance of such fishes as the alewife or fresh-water herring. While the sea foods once formed the bulk of their diet, and marine animals were adapted for many uses in their culture, the Wampanoag have gradually become less and less dependent upon marine resources, although they are still important as items of food. The ethnic character of these people has been described by Speck (1928).

Of all the marine invertebrates utilized by the Wampanoag, the pelecypods or bivalve mollusks have been of the greatest importance. Many species were common items of food, some were used in tempering clay for pottery, and some were used for beads, scrapers, and ornaments. The oyster (*Ostrea virginica*) was at one time a staple food. This mollusk lived in Menemsha Pond, and other salt-water ponds at Gay Head, and probably in sheltered bays along the southern shore of Cape Cod. In recent times this species has become scarce in the locality of this study. Efforts have been made by present day Indians to reintroduce the oyster into the salt-water ponds at Gay Head without success, so that now it is obtained only through commercial sources. In former times, however, the oyster was undoubtedly fished in large quantities and eaten frequently, as attested by the great bulk of oyster shells found in many of the excavated shell heaps. In modern times they are stored by spreading them over a basement floor with the deep shell down and sprinkled with corn meal, or packed in seaweed in a cool, dark place.

Equally important as the oyster was the bay scallop (*Pecten irradians*). This shellfish was also obtained from the salt-water ponds and inlets, and today still ranks first among local food mollusks. As in the case of the oyster, shell heaps reveal a large consumption of this bivalve. Some shell heaps are largely oyster shells; others are largely scallop shells. At times the two are mixed, and at other times there are alternating layers of the two species. The latter case may indicate fluctuations of abundance of these mollusks from one time to another, or the greater availability of one over the other at certain seasons. Besides food, scallops were used in the manufacture of pottery. Byers and Johnson (1940) found that "By far the greatest number of sherds are tempered with scallop shell." An interesting superstition of recent times among the Gay Head Indian people is the belief that domestic cats, which eat the rim of the scallop (edge of the mantle containing the eyes), have their ears rot off in a short time.

The quahog (*Mercenaria mercenaria*) ranks third in importance in the all-time list, although in recent times it shares with the scallop the honor of first place. Quahog shells are abundant in the shell heaps, and today it is the commonest clam consumed in the area. They are obtained by treading in shallow water and by the use of quahog rakes in deeper water. They are stored by spreading out on cool basement floors. In addition to steaming and frying, they are used in clam chowder, clam fritters, and clam pie. They have also been used for bait although less valuable shellfish are now substituted for that purpose. In pre-historic and proto-historic times purple wampum or beads were cut from the purple nacre of the quahog shells. Chase (1885) found quahog shells perforated in such a manner as to suggest they had been strung in the form of a necklace.

The soft-shelled clam (*Mya arenaria*) is another common bivalve that has been in use over a long period of time, but this species is no longer as important on the south shore of Massachusetts as it is and has long been along the coast north of Cape Cod, where it is more abundant and where the quahog or hard-shelled clam does not live in any significant quantity. South of

Table 1.—Marine Organisms Utilized by the Wampanoag Indians

[All invertebrates are listed by Sumner, Osburn, and Cole (1913) and fishes by Bigelow and Welch (1925) for the region. 1, Collected from Menemsha Bight by Lee (1944). 2, Collected from Menemsha Pond by Dexter and Jeffers. 3, Found in Marthas Vineyard shellheaps by Byers and Johnson. 4, Found in Nantucket shellheaps by Bullen and Brooks. 5, Reported by Wampanoag informants from Mashpee and Gay Head.]

	1	2	3	4	5
Algae:					
Fucus vesiculosis, rock seaweed		+			+
Ascophyllum nodosum, rock seaweed		+			+
Chondrus crispus, Irish moss					+
Pelecypoda:					
Argina campechiensis pexata, combed ark			+		
Ostrea virginica, oyster	+		+	+	+
Pecten irradians, bay scallop		+	+	+	+
P. grandis, deep sea scallop					+
Anomia simplex, jingle shell		+			+
Mytilus edulis, blue mussel		+	+		+
Volsella demissa, ribbed mussel					+
Mercenaria mercenaria, quahog		+	+	+	+
Ensis directus, razor clam		+			+
Spisula solidissima, sea clam		+	+		+
Tagelus gibbus			+		
Mya arenaria, soft-shelled clam			+	+	+
Gastropoda:					
Polinices heros, sand-collar snail		+	+		+
P. duplicata, sand-collar snail		+	+		+
Crepidula fornicata, boatshell	+	+	+	+	+
Littorina littorea, English periwinkle		+			+
Urosalpinx cinereus, oyster drill		+	+		
Nassarius trivittata, sand snail	+	+	+	+	
N. obsoletus, mud snail			+		
Buccinum undatum, English whelk					+
Busycon canaliculatum, pear conch		+	+	+	+
B. carica, pear conch			+		+
Cephalopoda:					
Loligo pealii, squid					+
Arachnoidea:					
Limulus polyphemus, horseshoe crab		+			+
Crustacea:					
Balanus balanoides, rock barnacle					+
B. eburneus (?), ivory barnacle			+		
Homarus americanus, lobster					+
Cancer irroratus, rock crab	+	+			+
Callinectes sapidus, blue crab		+			+
Carcinides maenas, green crab		+			+
Uca spp., fiddler crabs					+
Pisces:					
Squalus acanthias, spiny dogfish			+		+
Raja spp., skates					+
Acipenser sp., sturgeon			+		
Anguilla bostoniensis, eel					+
Pomolobus pseudo-harengus, alewife					+
Osmerus mordax, smelt					+
Scomber scombrus, mackerel					+
Pomatomus saltatrix, bluefish					+
Roccus saxatilis, striped bass					+
Morone americana, white perch					+
Centropristes striatus, sea bass					+
Stenatomus chrysops, porgy					+
Tautogolabrus adspersus, cunner					+
Tautoga onitis, tautog			+		+
Opsanus tau, toadfish					+
Merluccius bilinearis, whiting					+
Gadus morhua, cod					+
Pseudopleuronectes americanus, flounder					+
Reptilia:					
Sea turtles					+
Mammalia:					
Physeter catodon, sperm whale			+		
Globicephala ventricosa blackfish			+?	+	+
Porpoise					+
Phoca vitulina, harbor seal			+		
Halichoerus grypus, gray seal			+	+	

Cape Cod the quahog is now the most valuable of the clams. The soft-shelled clam has, however, been used for the same general purpose as the quahog—steaming, frying, chowder, fritters, pie—but in this case the stomach of the soft-shelled clam is usually removed because of its size and soft texture. This species is not stored because of its poor keeping qualities. It has also been used for bait. After the hurricane and tidal wave of 1938, the soft-shelled clams practically disappeared from the shores of Menemsha Pond. It is believed that they were buried and smothered. In any case this recent and sudden disappearance suggests that similar natural phenomena may be the explanation for variations in the composition of shells in the local kitchen middens from one period of accumulation to another. Byers and Johnson (1940) explained in part the variations in the composition of shell heaps studied by them as a function of the ease of obtaining certain species at certain times. Molluscan populations are known to fluctuate in abundance from time to time to a great degree, sometimes in a cyclical pattern. Some observations of this nature have been published by Dexter (1944). Over long periods of time the ecological balance may change drastically. Thus, for example, in 1931–32 the eelgrass completely disappeared from Menemsha Pond as it did in nearly all other localities along the Eastern Seaboard as the result of a wasting disease. There is evidence that eelgrass decline has been periodic. According to Linus Jeffers the eelgrass returned to Menemsha Pond in 1945. A note on the status of eelgrass in this pond in the summer of 1947 and its relation to the mollusks there has been published by Dexter (1947). Such drastic changes in the natural resources and the consequences of an upset ecological balance are bound to be reflected in the economy of a people who depend wholly or largely on local resources such as the Wampanoag did at one time. Periodic failure of marine populations may account for such conditions as reported by Miller (1880) who wrote that "this lack of food at Massasoit's home indicates a precarious state of subsistence with the Indians."

The sea clam or hen clam (*Spisula solidissima*) has been used for chowder and sometimes for clam pie, after being finely chopped up, but for little else because of its tough texture. It has been used extensively, however, for bait, especially for taking codfish. These clams are dug at low water during the perigee tides. The shells were formerly used for hoes and scrapers. Several other species of bivalves have also been used occasionally for food, but primarily for bait. These include the blue mussel (*Mytilus edulis*), the razor clam (*Ensis directus*), and the ribbed mussel (*Volsella demissa*). The intertidal bivalves were dug out of the muds and sands during times of low tide. In places where the sediments were unusually soft, making standing and walking difficult, the Indians sat down and slid over the flats to obtain the shellfish. Oysters, scallops, and quahogs are sometimes eaten raw. Possibly this practice was more common in older times. In the past century shellfish have been prepared by steaming, frying, stewing, and baking. At one time they were fried in skunk, groundhog, and bird grease. In recent times the shells of bivalves have been burned and used for liming the soil.

One bivalve, the common jingle shell (*Anomia simplex*), played a part in local (Gay Head) Wampanoag fables and myths, in which the shells are referred to as "Granny Squanit's toe nails." These were doubtless used as toys for children because of their bright golden and silver colors and the jingle sounds which they make. On the Chesapeake Bay region the modern Indians string them to make necklaces for their costumes.

Two species of bivalves were recovered from the Vineyard Shell Heap by Byers and Johnson (1940) for which no special use is known. They are *Tagelus gibbus* and the combed ark shell, *Argina campechiensis pexata*. Not many have been recovered, and since they are subtidal forms, they may have been acquired only incidentally along with the collection of common food mollusks. One species which has been used only in recent times is the deep-sea scallop (*Pecten grandis*) which the aboriginal inhabitants doubtless had no means of securing.

It is interesting that fresh-water clams, common in Mashpee Pond, and probably in others as well, never seem to have been utilized either in former or in recent times. Many of the present-day Indians believe them to be poisonous, and the easily available and more palatable marine clams left the fresh-water forms without value.

The marine gastropods or snails also played a leading part in the economy of the Wampanoag. The winkles or pear conchs (*Busycon canaliculatum* and *B. carica*) were ground up, made into a paste, and eaten on bread. A hash and a chowder were also prepared by boiling the chopped snails with vegetables. These snails were also used for bait, and the largest of the shells were used for trumpets. White wampum was manufactured from the columella of these shells. The sand collar snails (*Polinices heros* and *P. duplicata*) and, in recent times at least, the whelk (*Buccinum undatum*), were likewise utilized for food and bait. Boatshells (*Crepidula fornicata*) have long been eaten and are commonly called "sweetmeats." Three species of snails, the sand snail (*Nassarius trivittata*), the mud snail (*N. obsoletus*), and the oyster drill (*Urosalpinx cinereus*) have been found in shell heaps, but there is no evidence as to the nature of their use, if any. The last species named probably reached the refuse piles accidentally on the shells of oysters through which it drills to obtain its food. The other two species may also have been collected incidentally when the food mollusks were gathered.

It is not clear as to what species Chase (1885) refers to by the name of "periwinkle" which he found in Wampanoag shell heaps. Besides having found them in shell deposits, some of the shells perforated for stringing, he reported on a skeleton discovered in South Wellfleet with a necklace consisting of "a double row of common periwinkles." Chase (1885), Byers and Johnson (1940), and Bullen and Brooks (1947) all reported finding small clusters of land snails among the marine shells. Some of these land shells may have been eaten by the natives and possibly some may have been strung for ornaments. However, Ingram (1944) has described the underground storage of land snails by shrews, which behavior should not be overlooked as a possible explanation for the occurrence of such shells in kitchen middens. The two species recovered by Byers and Johnson (1940) and Bullen and Brooks (1947) are among those cited by Ingram in his study. Also, the notation by Byers and Johnson (ibid.) that *recent* shells of a third species of a land snail were found in the heaps indicates without question that they were deposited by some subterranean animal, and very possibly by a shrew.

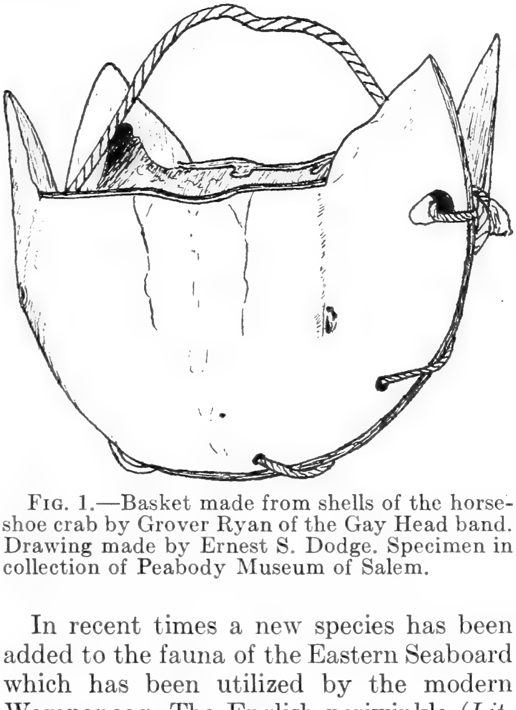

Fig. 1.—Basket made from shells of the horseshoe crab by Grover Ryan of the Gay Head band. Drawing made by Ernest S. Dodge. Specimen in collection of Peabody Museum of Salem.

In recent times a new species has been added to the fauna of the Eastern Seaboard which has been utilized by the modern Wampanoag. The English periwinkle (*Littorina littorea*), which was introduced into North America at the Gulf of St. Lawrence, spread southward very rapidly. According to Morse (1880), this snail was collected at Barnstable on Cape Cod Bay in large quantities in 1875. That year it was rare at Woods Hole on the southern shore of Cape Cod, but by the following year it had become a common species there. These were eaten by the coastal Wampanoag as boiled snails and, after being cooked with vegetables, in the form of hash.

Present-day Indians also eat the common squid (*Loligo pealii*), a cephalopod mollusk. We have no information as to how far back

in time this practice extended. The internal pen or skeleton of this animal would not likely remain preserved in rubbish heaps.

Although the horseshoe crab (*Limulus polyphemus*), one of the most primitive forms of arthropods alive, goes untouched today, it was used extensively in the nineteenth century, if not earlier. First of all it was an item of food. It was boiled and the eggs or roe were eaten much as lobster eggs were eaten at one time. Some also ate the meat from the legs. Then too the shells were used as boat bailers. Other shells, matched for size, were tied together rim to rim to make baskets (Fig. 1). The tails were used as needles and awls. They were also fastened on sticks and used as improvised spears by hunters wading at low tide in shoal water, for the capture of bottom fishes, especially the flounder (Fig. 2). Finally, the chelicerae of the males were saved, polished with repeated rubbing, and carried as good-luck charms. These were commonly called "lucky bones" (Fig. 3).

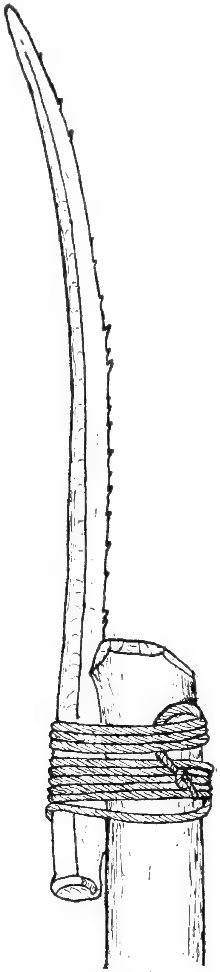

Fig. 2.—Spear made from tail of the horseshoe crab by Jerry Diamond of the Gay Head band. Nearly natural size. Drawing made by Ernest S. Dodge. Specimen in collection of Peabody Museum of Salem.

Fig. 3.—"Lucky bones," or chelicerae of the horseshoe crab. Natural size. Drawing made by L. R. Tcherky. Specimens in collection of Peabody Museum of Salem.

One informant (Ambrose Pells) reported that he has eaten rock barnacles (*Balanus balanoides*). It is known that in certain areas where large species of barnacles grow they are used to prepare a stew, especially when they are filled with eggs. Probably barnacles were little used by the Massachusetts Indians, however, except possibly as an emergency food. Byers and Johnson (1940) list what is believed to be the ivory barnacle (*Balanus eburneus*) from a shell heap excavated by them. This is a subtidal species, and without question owes its presence in the shell heap to the fact that it was attached to a mollusk shell and hence was collected only incidentally. Other crustaceans, on the other hand, have been valuable items in the food of the Wampanoag. The lobster (*Homarus americanus*) has long been a choice sea food. It was reported by Mrs. Bessie Sturgis that her husband's grandfather was known to capture lobsters with an iron hook in the 1840's and 1850's. These he placed in a back-basket of woven ash while he continued to fish out more of

them from the sand and among the rocks. Later the Indians adopted the white man's method of using lobster pots. For the latter, skate slash was used as bait, the skates being taken by spearing them from a boat with a single-barbed iron spear. Crabs were also captured for food, usually by spearing. The blue crab (*Callinectes sapidus*) has been the most valuable one, but green crabs (*Carcinides maenas*) and rock crabs (*Cancer irroratus*) have been eaten somewhat as well as being used for bait. The fiddler crabs (*Uca* spp.) have been used for bait only.

In spite of the large number of marine invertebrates that have been utilized in one form or another by the Wampanoag, no indication has ever been made of using the echinoderms, the only major group of marine animals for which no information on utility is available. While the white man who settled and has lived on the coast of North America has likewise neglected possible uses of the echinoderms, Europeans have long relished the food value of the sea-urchins, and the sea-cucumbers are eaten in the Far East.

The marine vertebrates, especially the fishes, have also been a very important group in the economy of the Wampanoag people. The most valuable one was the alewife (*Pomolobus pseudo-harengus*), more commonly called locally the fresh-water herring. This should not be confused with the true herring (*Clupea harengus*). The fresh-water herring is an anadromous fish, penetrating into fresh-water ponds from the sea for spawning. It was at such times of migration that the Indians caught them in great quantities and preserved them for future use. Smoked herring was a stable winter food on Cape Cod for many years. During the "run" of the herring, nets were placed in the streams leading to the breeding ponds. The nets were made of twine with a mesh two fingers in width. Only the fingers were and still are used in measuring the mesh, not a wooden gauge. One type of net was square with the corners and center tied to a pole which served to lift the net from the water. Stone sinkers were attached to submerge the nets. Notched sinkers have been recovered from a number of excavations, and Byers and Johnson (1940) reported that such sinkers are still in use today at Gay Head. The herring were salted on the streambank at the time of collection and placed in barrels for four days. They were then dried for three days, after which they were smoked in a smoke house. The fish were suspended on a stick pushed through the eyes, with a dozen or so spaced on one stick. White oak, sugar maple, and sweet fern were burned to produce the smoke. At one time a thousand barrels were taken each season from the Mashpee River. A generation ago each family at Mashpee consumed on the average 300 smoked herring a year. Today the average is no more than two or three dozen. In recent times herring have been smoked by Edward Amos, Tom and Russell Mingo, and George Avant at Mashpee. The first named is the only one continuing the practice today. As far as can be learned, fresh-water herring were never smoked at Gay Head.

The eel (*Anguilla bostoniensis*) was speared in shallow water and salted for preservation. Chase (1885) mentioned that the Indians at Mashpee sought the eels at night from a canoe with the aid of a torch. The flatfish or flounder (*Pseudopleuronectes americanus*) and the striped bass (*Roccus saxatilis*) were speared with the tail of a horseshoe crab attached to a stick as mentioned earlier, or with a stick having a short, sharp side branch at the bottom which served as a barb. Codfishing has been pursued off No Man's Land for many years and continues to the present time, although to a much less extent in recent years. In addition to the flesh, the liver and the sounds (air sacs) are boiled for food. When fish chowder is made, the sounds are left in the fish. The roe is fried. Lucky bones (probably otoliths) were formerly obtained from the head of the cod and carried as a charm. Mrs. Bessie Sturges of Mashpee recalls her grandfather, George Oakley, carrying two such lucky bones. The liver of the spiny dogfish (*Squalus acanthias*) was collected for extraction of oil for lamps. Fred Gardner claims that toadfish or puffer (*Opsanus tau*) was given to sick people to eat because it was believed to be very easily digested. Other fishes in the diet of the Wampanoag

include the following: Skates (*Raja* spp.); smelt (*Osmerus mordax*); mackerel (*Scomber scombrus*); bluefish (*Pomatomus saltatrix*); white perch (*Morone americana*); sea bass (*Centropristes striatus*); porgy (*Stenatomus chrysops*); cunner, or choksi (*tcákse*), as it is called by the Wampanoag (*Tautogolabrus adspersus*); tautog (*Tautoga onitis*); and whiting (*Merluccius bilinearis*). Miscellaneous and unidentified fish bones have been found in many of the shell heaps which have been studied. Remains of one fish have been found in these refuse piles which no longer lives in the area—Byers and Johnson (1940) uncovered scales of a sturgeon (*Acipenser* sp.). Fish weirs were built in shallow water with nets having notched stone sinkers tied to them for anchorage. Guernsey (1916) quotes from the Massachusetts Historical Collections which describe another method of capturing fish by the Wampanoag as follows. A passage was opened from the sea to Great Pond (now called Squibnocket Pond). Hurdles were sunk to the bottom of the connecting channel in a horizontal position. After the fish had entered the pond, the hurdles were raised to prevent the escape of the fish, which were then sought by spearing from canoes in the shallow water of the pond.

Rock seaweeds (*Fucus vesiculosis, Ascophyllum nodosum*) have been used for keeping the catch of marine animals cool and moist until they were ready for use. This practice is continued today at Gloucester by the world's largest distributor of lobsters, who ships live lobsters all over North America packed in barrels of rock seaweeds. Also, these algae have long been used as packing materials for the famous New England clam bakes. Guernsey (1916) discovered a bundle of seaweed at the bottom of a pit which he believed may have been used as a mattress. The red alga known as Irish moss (*Chondrus crispus*) was used as a source of gelatin.

While there is no archeological evidence that sea turtles were ever captured, such have been eaten in modern times at least. The tooth of a sperm whale (*Physeter catodon*) found by Byers and Johnson (1940) indicates that stranded whales were utilized by the ancient Wampanoag. Remains of a smaller whale, the blackfish (*Globicephala ventricosa*) have also been recovered from shell heaps, and there are historical records which give further information. Chase (1885) quotes an observation made by an exploring party of Gov. John Carver which discovered Wampanoag cutting up a blackfish on the shore of what is now called Blackfish Bay. Both the flesh and the oil were used. When the whaling industry of Massachusetts developed, Wampanoag from Cape Cod and Marthas Vineyard were among the whaling crews. On their trips, porpoises, among other things, were captured for food. Bones of the harbor seal (*Phoca vitulina*) and the gray seal (*Halichoerus grypus*) have been identified from shell heaps, but these animals have not been used for many years, and the gray seal is no longer found in the region.

An ancient tribal festival of the Indians at Gay Head has persisted to the present day. The annual occasion, once a week-long affair, is now referred to as Cranberry Day. The Indians come to the town cranberry bogs for harvesting the crop at the height of the season and to have a social gathering of the townspeople. The youths entertain themselves with games, sports, and contests, and a feast is prepared with shellfish taken from Menemsha Pond nearby. Quahogs, scallops, and clams have been the main foods for some time, but formerly oysters were gathered as well. Guernsey (1916) found two small shell heaps in the dunes close by the cranberry bogs and believed they contained the refuse from such an occasion. In the old wigwam days the inhabitants assembled after driving to the bogs in ox carts. One of the tribal rites at these affairs has come down to recent times, within the memory of living Indians. At the feast, a child was given a basket of food to carry into the dunes to set down at a lonely spot as a gift to old Granny Squanit, and cautioned to hurry away without ever looking back.

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PHYSICS.—*Transition from international to absolute electrical units as it affects the physical chemist.*[1]

George W. Vinal, National Bureau of Standards.

Revised values of the units of electricity and light, effective January 1, 1948, have been adopted pursuant to decisions of the International Committee on Weights and Measures. The definitions of the new "absolute" units and the methods of fixing their magnitudes are quite different from those formerly employed for the practical system of units in use from 1911 to 1947, but the actual changes in magnitude are small and affect only measurements of high precision.

The object of this paper is to indicate briefly (1) what has been done; (2) why a change was made at that time; (3) how much the units are altered; and (4) how the change does or does not affect calculations of the physical chemist in such matters as electrode potentials, activity coefficients, pH, the calorie, free energy, conductivity, and other items.

The absolute system of electrical units is derived from fundamental mechanical units of length, mass, and time by the use of accepted principles of electromagnetism, with the permeability of space taken as unity in the centimeter-gram-second units or as 10^{-7} in the corresponding meter-kilogram-second units. Electrical measurements are thus made concordant with measurements in other fields of science and engineering. This is a guiding principle which has been recognized as desirable since Weber proposed it in 1851. Theoretically this principle is most important, but practically the difficulties in making precise electrical measurements in terms of mechanical units were very great.

An electrical congress, comprising official delegates (Fig. 1) from various countries, met at the World's Fair in Chicago in 1893 and agreed upon definitions for electrical units, recognizing in principle the absolute system but providing concrete standards to represent them. Public law No. 105, 53d Congress, approved July 12, 1894, embodies the decisions of this international body but contains ambiguities which were not recognized until many years later.

As time went on greater accuracy of the standards was needed, and an International Conference on Electrical Units and Standards, meeting in London in 1908, took definitive action to recognize the absolute system of units, but established for practical purposes a separate and independent system based on concrete standards, the mercury ohm, the silver voltameter, and the standard cell.

The electromotive force of the Weston Normal Cell was determined experimentally by a committee, including representatives from four countries who met at the National

[1] This paper was presented on April 19, 1948, at a symposium on batteries and galvanic cells, American Chemical Society, Chicago, Ill. Received June 10, 1948.

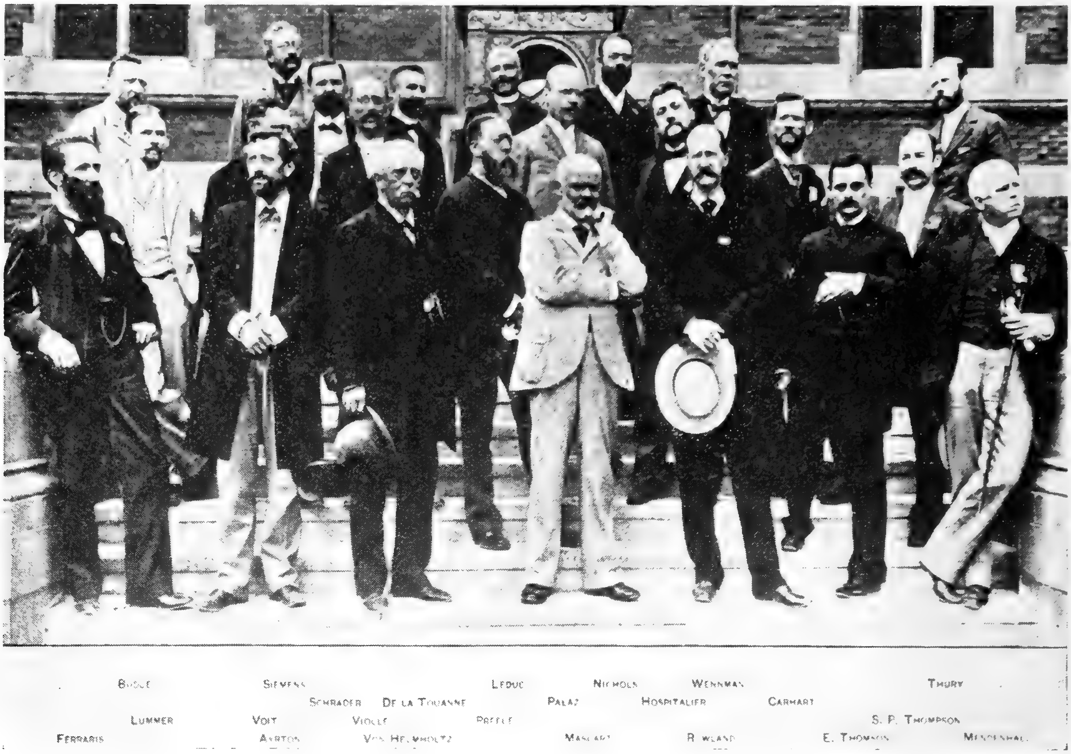

Fig. 1.—Official delegates to the International Electrical Congress held at Chicago, 1893. (Courtesy of "Weston Engineering Notes".)

Bureau of Standards in April 1910 (Fig. 2). The international electrical units, in use from 1911 to 1947, were based on these standards. Subsequent measurements of the ohm and ampere revealed differences between the units as realized from these concrete standards and the absolute units based on length, mass and time. The largest discrepancy was in the ohm, amounting to about 1 part in 2,000. Precise measurements of the present day make it very desirable, therefore, that a readjustment should be made.

This step has not been taken without mature deliberation. The American Institute of Electrical Engineers recommended it 20 years ago. The National Bureau of Standards, charged with maintaining the units in this country, consulted an advisory committee consisting of representatives appointed by leading scientific and engineering bodies. The Eighth General Conference on Weights and Measures (an international body) approved the change, which was set for 1940, but for obvious reasons postponed until the present time.

The relation of the fundamental units to the measurement of power and energy in both the new and former systems of units is shown diagrammatically in Fig. 3. The left half represents functions of the National Bureau of Standards, the right half the units and certified standards as you use them in the laboratory. Details of the steps taken may be found in Circular C459 of the National Bureau of Standards, issued May 15, 1947.

MAGNITUDE OF THE CHANGE

Units of the new system will be maintained, as in the past, by standard resistors and standard cells with reassigned values. The relative magnitudes of the ohms and volts in the two systems as accepted by the International Committee on Weights and Measures in October 1946 are as follows:

1 mean international ohm = 1.00049 absolute ohms
1 mean international volt = 1.00034 absolute volts

These are averages of units maintained in national laboratories of France, Germany, Great Britain, Japan, U.S.S.R., and the United States, which took part in the work before the outbreak of the war.

Specifically, the units maintained in the United States by the National Bureau of Standards have differed from the above averages by a few parts in a million, so that the conversion factors for adjusting the above and other values in this country are as follows:

1	international	ohm (US)	=1.000495	absolute	ohms
1	"	volt (US)	=1.00033	"	volts
1	"	ampere (US)	=0.999835	"	ampere
1	"	coulomb (US)	=0.999835	"	coulomb
1	"	henry (US)	=1.000495	"	henries
1	"	farad (US)	=0.999505	"	farad
1	"	watt (US)	=1.000165	"	watts
1	"	joule (US)	=1.000165	"	joules

These factors should be used in converting values in certificates of the NBS issued previous to January 1, 1948, to the present absolute units.

EFFECT ON CALCULATIONS OF THE PHYSICAL CHEMIST

The calory and thermodynamic quantities.—At various times, quantities of heat energy have been measured in mechanical units, in electrical units, and in thermal units. Various calories, specifically defined, as units of heat energy and based on the absorption of heat by water were measured thermally until about 1910, when it became more usual to measure them in international joules. Difficulties were encountered in introducing the joule as a substitute for the traditional calory and this led to the adoption of an artificial calory[2] for thermochemical purposes. It was defined without reference to water as—

[2] E. F. MUELLER and F. D. ROSSINI, *The calory and the joule in thermodynamics and thermochemistry.* Amer. Journ. Phys. 12: 1. 1944.

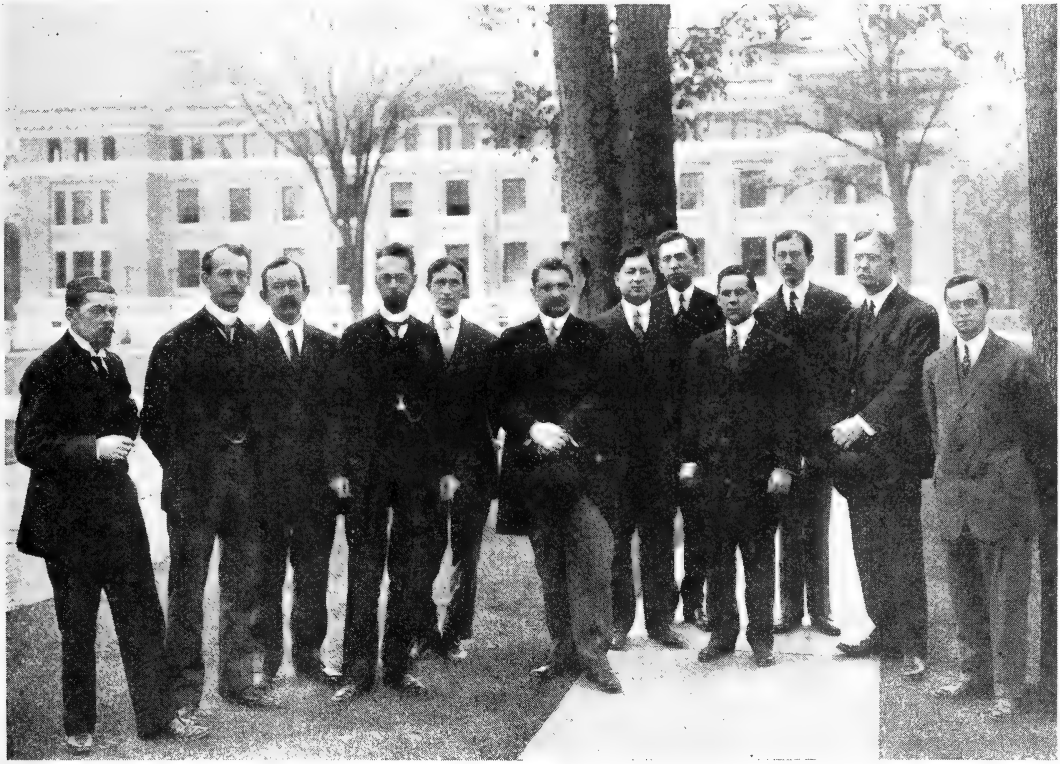

FIG. 2.—Members (*) of the International Technical Committee of 1910 and assistants at the National Bureau of Standards. Left to right. F. Laporte* of France, Sir Frank Smith* of England, Dr. F. A. Wolff*, Dr. W. Jaeger* of Germany, M. P. Shoemaker, Dr. S. W. Stratton*, Director N.B.S., Dr. F. Wenner, Dr. A. S. McDaniel, G. E. Post, Dr. F. W. Grover, Dr. E. B. Rosa*, Dr. G. W. Vinal.

1 calory = 4.1833 international joules (NBS).

With the transition from international to absolute units, the calory remains the same but the above relation becomes

1 calory = 4.1840 absolute joules.

Likewise various thermodynamic quantities such as the increment of internal or intrinsic energy, ΔE; increment of heat energy, ΔH; the product of absolute temperature by the change in entropy, $T\Delta S$; the increase of free energy, ΔF; are unchanging physical quantities expressed numerically as joules per mole. Old values in international joules can be converted to corresponding absolute joules by multiplying by the factor 1.000-165.

Table of corrections.—A considerable number of quantities with which the physical chemist has to deal is listed in Table 1.

Table 1.—Correction Factors

Quantity	Unit of corresponding dimensions	Correction factor int. to abs. units
Activity coefficient	(dimensionless)	no change
Gas constant R	joule, deg^{-1} $mole^{-1}$	×1.000165
Faraday F	coulomb, g-$equiv^{-1}$	×0.999835
Factor RT/nF	volt	×1.00033
Stand. elec. pot. E°	volt	×1.00033
Redox potentials	volt	×1.00033
Ionization constant	(dimensionless)	no change
Energy & work	joule	×1.000165
Values of pH	(dimensionless)	no change
Brit. Therm. unit	joule	×1.000165
Resistivity	ohm, cm	×1.000495
Conductivity (elec)	ohm^{-1}, cm^{-1}	÷1.000495
Ampere-hour	coulomb	×0.999835
Electric potential	volt	×1.00033
Electric field strength	volt, cm^{-1}	×1.00033
Ionic mobility	$volt^{-1}$, cm^2, sec^{-1}	÷1.00033
Free energy change	volt, coulomb	×1.000165
Electron charge (emu)	coulomb	×0.999835
Electron volt (emu)	coulomb, volt	×1.000165

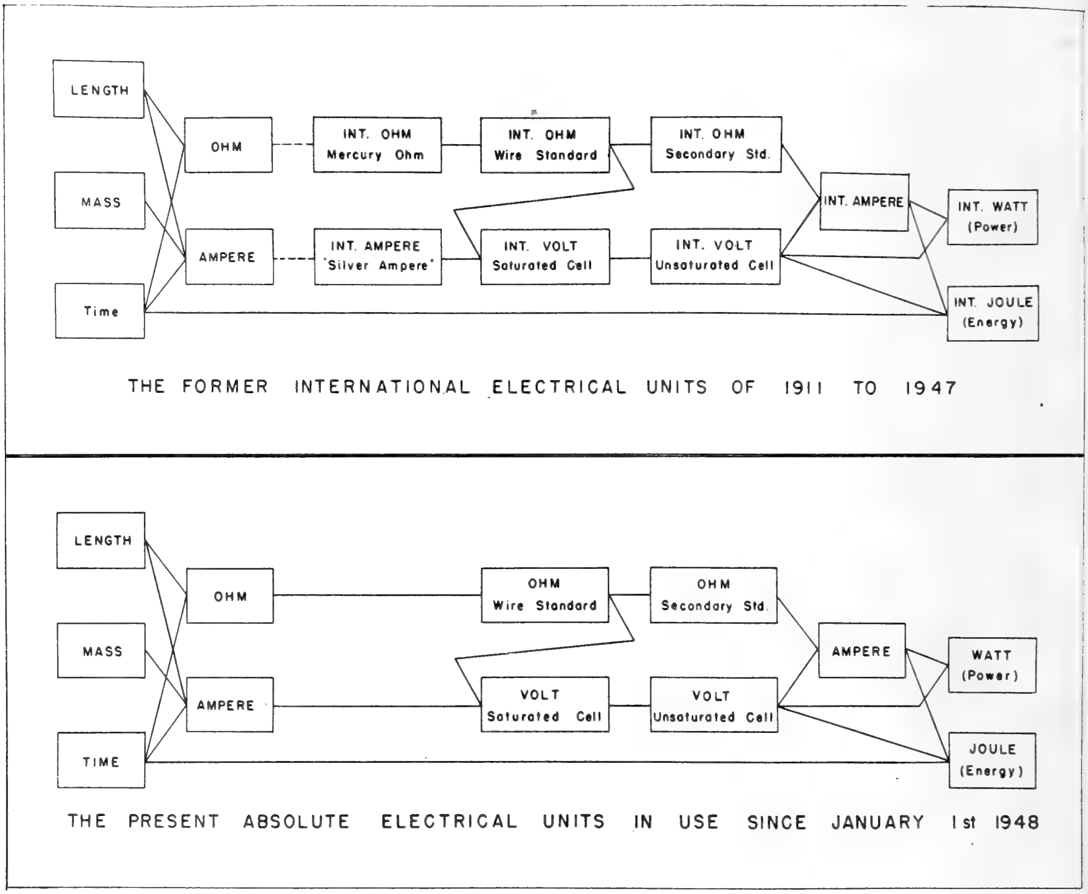

Fig. 3

The corrections given in the last column are factors by which values in international units are to be multiplied (×) or divided (÷) to give the corresponding value in absolute units, provided that electrical measurements are involved. Doubtless the list might be considerably extended but enough are reported to illustrate the principles involved.

The international temperature scale.—Measurements on the international temperature scale by the use of electric thermometers are little, if at all, affected by the change in units. Platinum resistance thermometers involve a ratio of resistances. This is obviously dimensionless and independent of the units. Thermocouple measurements are affected only at high temperatures. At the gold point the correction is 4 microvolts and from this corrections at lower temperatures can be estimated.

BOTANY.—Heliopsis longipes, *a Mexican insecticidal plant species.*[1]

Elbert L. Little, Jr., U. S. Forest Service.

Heliopsis longipes (A. Gray) Blake (family Compositae), common name "chilcuague," is a Mexican herbaceous plant species of possible commercial value as a source of insecticide. In testing various wild plants for new insecticides during the late war, the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, found root extracts from this species to have the same order of paralyzing action and toxicity to house flies as pyrethrins and to be toxic also to other insects.

The dried roots without botanical material for identification had been submitted from a Mexican company under the name *Erigeron affinis* DC. (family Compositae), common names "pelitre del país" and "chilcuán." Acree, Jacobson, and Haller (*1, 2, 5*), of the bureau mentioned, isolated from the roots the toxic principle, which they identified as N-isobutyl-2, 6, 8-decatrienoamide and which they named "affinin," from the reported scientific name, Toxicity tests against house flies, mosquitoes, and other insects were made by McGovran and others (*6*), of the same bureau. On the basis of these investigations, R. C. Roark (*11a*), also of this bureau, recently included this species among promising insecticidal plants meriting further research. It seems appropriate, therefore, to report upon the botanical aspects of this insecticide, especially since the scientific name has been confused and not previously known.

The name *Erigeron affinis* for the samples tested apparently was taken from the reference books on Mexican plant names, useful plants, and medicinal plants by Martínez (*7, 8, 9, 10*), who also cited older publications. The early physician Dr. Francisco Hernández (1514–1578), in a work first published in 1615, described a plant, "chilmecatl" or "ychcha," the slender roots of which relieved the toothache and other pains (*4*, pp. 383–384; *15*, p. 121). His description, which Martínez referred to *Erigeron affinis*, is not that of *Heliopsis longipes*.

Erigeron affinis was mentioned in 1902 in Noriega's (*11*, p. 419) Mexican reference on medicinal plants as a substitute for "peritre de Africa," *Anacyclus pyrethrum* DC. and *Anthemis pyrethrum* L., used for rheumatism, neuralgia, toothache, etc., in the following statement (translated from Spanish): "Substituted for it is the root of "chilcuam' or 'peritre del país,' *Erygeron affinis*, which is abundant in the surroundings of Mexico City and is probably the same root abundant in the Sierra de Querétaro, known by the name of 'chilcuán' and *Spilanthes leccabunga* [*beccabunga*] DC., found in Tizapán; their properties appear to be identical."

The following year a chemical analysis of the root of chilcuán (*Erigeron affinis*) by Prof. D. Miguel Cordero (*14*, pp. 237–254) was reported. Escobar (*3*, **1**: 1015, 1194; **3**: 93) in his encyclopedia on agriculture mentioned *Erigeron affinis*, with the com-

[1] This study was made while the author was employed in Mexico in 1945 as production specialist (drugs), by the United States Commercial Company, an agency of the United States Government. Received May 25, 1948.

mon names "chilcuán," "chalchuán," "pelitre," "pelitre del país," and "peritre del país." Santamaría (*12*, **1**: 492–493; **2**: 450; **3**: 450) listed for this species the common names "chalchuán," "chilcagüe," "chilcuague," "chilcuahui," "chilcuán," "pelitre," and "peritre," and associated *Spilanthes beccabunga* with some of these names also.

Martínez' (*7*, pp. 152–155; *9*, pp. 110–112) description of "chilcuán," "chilcuam," or "chilcuague," *Erigeron affinis* DC., as a plant with alternate leaves and white or violet flowers agrees with *Erigeron* and not *Heliopsis longipes*. However, his drawing shows a group of 10 small flower heads on a peduncle, while *Erigeron affinis* has large, solitary, long-peduncled heads. He mentioned various uses for the roots, including stimulation of flow of saliva, relief from toothache, as a dentrifrice, as an insecticide (from the smoke produced by burning), and as a spice substituted for chile in flavoring foods. In San Luis Potosí an alcoholic tincture was applied for pimples, itch, and lice.

Apparently the roots of two or more genera of Compositae with similar properties and similar common names have been confused in the absence of complete botanical specimens. As *Erigeron affinis* was not included in my study, there is no reason to doubt the descriptions of its properties by the authors cited. In May, June, and July, 1945, I made field studies of "chilcuague" in northeastern Guanajuato and collected flowering material, which Dr. S. F. Blake kindly determined as *Heliopsis longipes* (A. Gray) Blake. Earlier references of "chilcuán" from Querétaro, Guanajuato, and San Luis Potosí may apply in part to the same species. A different kind of "pelitre" or "chilcuague," with weaker properties, collected for me by Henry W. Turner at Zamora, Michoacán, was identified by Dr. Blake as *Spilanthes ocymifolia* (Lam.) A. H. Moore. A compound similar to affinin, spilanthol, has been isolated from flower heads of another species of *Spilanthes*.

The discovery of an insecticide in *Heliopsis longipes* is of special interest, as apparently there are no previous reports of insecticidal or medicinal properties in this genus. *Heliopsis* Pers., a genus closely related to *Zinnia* L., consists of about 10 species of American herbs, distributed from Canada and the United States south through Mexico and Central America to Peru. Two of the four species native in the United States, *H. helianthoides* (L.) Sweet and *H. scabra* Dunal, are widely distributed weeds with yellow flower heads resembling sunflowers and have been cultivated as hardy ornamentals. It would be desirable to determine whether other species of this genus have insecticidal properties.

DESCRIPTION OF HELIOPSIS LONGIPES

Heliopsis longipes (A. Gray) Blake, Contr. U. S. Nat. Herb. **22**: 608. 1924.

Philactis longipes A. Gray, Proc. Amer. Acad. Arts and Sci. **15**: 35. 1879.

Common names: "chilcuague," "chilicuague," "pelitre."

Perennial herb or with stems slightly woody and shrubby at base, 2 to 5 dm tall, hirtellous, with one or more stems, spreading and curved to nearly erect, usually unbranched above base, 3 to 7 dm long. Leaves opposite, few, short-petioled, the blades ovate, about 2 to 4 cm long, dentate-serrate. Peduncles 1 to several, terminal, elongate, 10 to 25 cm long, each with a solitary flower head. Involucre of 7 to 9 green ovate or lance-ovate bracts 7 to 10 mm long. Receptable columnar elongated, 10 to 20 mm long. Flowers yellow, rays fertile, about 10, the lamina sessile, about 15 to 18 mm long and 6 mm broad, achenes trigonous—obcompressed, without pappus. Disk flowers fertile, quadrangular and few ribbed, without pappus or with 2 or 4 minute teeth. Bracts of the receptacle 6 to 7 mm long, yellow or orange-tipped, projecting beyond the disk flowers.

This description based upon my additional specimens is modified slightly from that by S. F. Blake (*13*, p. 1527) of the two previous collections, in which the leaves were smaller (to 2.5 cm long) and the rays shorter (about 1 cm long). *Heliopsis longipes* is generally a perennial herb forming new shoots each year from the perennial root system but was properly included by Blake as a "suffrutescent" species in the *Trees and shrubs of Mexico*. Though most stems die back to the ground each autumn, a few of the lowest, purplish internodes, or

sometimes more, may survive the winter and dry spring. Old stems in protected places beneath shrubs may be as long as 6 to 7 dm and only about 1.5 mm in diameter throughout their length. There are also horizontal stems, or rhizomes, near the surface or in leaf litter.

The roots are distinctive, usually fascicled or sometimes single, slightly fleshy, light brown, about 1.5 to 3 dm long and 3 to 4 mm in diameter. These slightly fleshy roots are unbranched, except for a few fibrous lateral roots, and spread out and down at angles in the soil. The leaves are variable, from ovate to oval and from nearly entire to conspicuously toothed. Small, young leaves have relatively denser whitish pubescence. Though usually there are only 1 or 2 flower heads, large plants may have as many as 10 or more flower heads borne on separate elongated peduncles, to which the specific name alludes.

Field recognition of chilcuague in the dormant season is difficult because the plants are low and inconspicuous, with nearly dead stems. However, positive identification can be made by a taste of the roots. In the spring small, immature leaves less than 1 cm long appear on short axillary branches. Growth of stems and leaves is most active in the growing season of summer rains from June to September. Flowers are produced from July to September.

GEOGRAPHIC DISTRIBUTION

Heliopsis longipes is known from southern San Luis Potosí and northeastern Guanajuato and has been reported from northern Querétaro. It is so restricted in geographic distribution and so infrequent that it was known previously to botanists from only two collections in San Luis Potosí, both deposited in the United States National Herbarium. These are the type, collected by C. C. Parry and Edward Palmer (*No. 465*) in 1878 "in valleys along the foothills of the mountains near San Luis Potosí" and the second, by J. G. Schaffner (*No. 763/338*) in 1879. Herb dealers in the city of San Luis Potosí told me in October 1945 that chilcuague grows in the mountainous area south and southeast towards Alvárez. In the State of San Luis Potosí it is restricted apparently to the mountains in the southern part, near the border of Guanajuato, as most of the State is too low in elevation and too arid for it.

In Guanajuato I located *Heliopsis longipes* only in the mountainous area east and north of San Luis de la Paz, about 40 kilometers (25 miles) square. Scattered colonies occur near the highway from San Luis de la Paz east to Xichú. Localities near which this species occurs include: Hacienda de la Mesa, Palmillas, Vergel, Macuala, Ahorcados, La Cueva, Charco Azul, and Santa Catarina. My specimens from several localities have been deposited in the United States National Herbarium and Herbarium of the National Arboretum.

The altitudinal zone of chilcuague in northeastern Guanajuato is from about 1,825 to 2,250 meters (about 6,000 to 7,400 feet). This mountainous area just east of the Continental Divide in the headwaters of the Atlantic drainages is exposed to the easterly winds and receives a higher precipitation than the plateau area around San Luis de la Paz and westward. San Luis de la Paz, elevation 2,020 meters (6,626 feet), is in the semidesert zone and has an annual rainfall of about 370 mm (15 inches). The oak-forest zone, in which chilcuague occurs, extends down the eastern slopes to about 1,825 meters (6,000 feet) near Xichú, elevation 1,400 meters (4,600 feet) and on the western slope near San Luis de la Paz to about 2,125 meters (7,000 feet).

HABITAT

"Chilcuague" (*Heliopsis longipes*) is an undergrowth species of the oak forest, or oak-pine forest, though neither widely distributed nor characteristic. This forest, generally open, is characterized by small oaks ("encinos") 5 to 12 meters or more in height and about 10 to 40 cm. D. B. H., with small to large, thick, evergreen leaves. In some areas the larger trees have been cut for charcoal. The species represented include *Quercus rugulosa* Mart. & Gal., *Q. lanceolata* Humb. & Bonpl., and *Q. macrophylla* Née. Occasionally pines ("pinos"; *Pinus teocote* Schlecht. & Cham.) are associated with the oaks. "Tejocote" (*Crataegus* sp.) is common in places, and

"madroño" (*Arbutus xalapensis* H. B. K.) is relatively sparse. The undergrowth includes scattered herbs and low shrubs, and grasses are characteristic of the open slopes. A few widespread herbaceous species of Compositae resemble chilcuague in having similar yellow flowers and opposite leaves but may be distinguished readily by their smaller, fibrous roots without the peculiar, burning and numbing taste.

Rare and scattered in the oak forests, chilcuague generally is found on the best sites, where the trees are larger and denser, such as gradual to steep, well-drained slopes of mountain sides and canyons. In one area chilcuague plants were observed in open pastures and shrub thickets where the oaks had been cleared. Preliminary observations indicate that plants in partial sunlight grow more rapidly, become larger, flower earlier in the season, and have better-developed root systems than plants in dense shade.

This species has been found only in areas with fertile top soil and adequate soil moisture, usually with a litter of oak leaves, humus, and organic loam soil 10 cm or more in depth. The mineral soil varies from sandy to clay and may be rocky. The entire soil layer on these slopes is only about 30 cm deep, overlying purplish volcanic rock. Chilcuague was not observed on the poorer sites, such as eroded slopes with mineral soil exposed and areas where the undergrowth had been damaged by recent fires.

Soil samples from five localities were analyzed with the Lamotte field tests. The soils were slightly acid, with pH of 6.4 to 6.8. The only serious deficiency was the low nitrogen content of most samples. Phosphorus was average, potassium average to high, sulphates low, and replaceable calcium high.

Small black beetles about 3 mm long and common on the flower heads were determined by H. S. Barber, of the Bureau of Entomology and Plant Quarantine, as *Pristocelis* sp. (family Dasytidae).

ACTIVE PRINCIPLE

When a very small piece (1 or 2 mm long) of fresh or dried chilcuague root is chewed, there is a strong numbing, burning sensation, somewhat anesthetic or paralyzing, in the adjacent parts of the mouth and tongue, lasting for several minutes. Secretion of saliva is stimulated also. In the roots this peculiar, strong taste is nearly all in the outer fleshy part, the pericycle, and very slight in the smaller, fibrous, inner part, mostly xylem. Cut fresh roots have a weak odor similar to the taste. If it is associated with this taste, the active insecticidal principle is almost limited to the underground parts, both the fleshy roots and rhizomes.

Green stems of the current year show a weak but characteristic taste test throughout their length to the flowers. This taste was not detected in old, woody stems of the previous year nor in the leaves. However, the leaves, green stems, and flowers do have a slightly resinous taste common to many composites. The flower heads, including bracts and rays, have a stronger taste than the green stems but weaker than the roots.

It would be desirable to test the flowers to determine whether the active principle is present in significant quantities. It is not known whether the active principle varies significantly in different plants or with age or season.

USES

Use of chilcuague roots is small and mostly restricted to the localities where the species is native. Persons living in the mountains bring in a few bunches to town on the weekly market day. The roots are dug with a pointed steel bar about 0.6 meter long or a similar tool. In being air dried, the roots lose in moisture about two-thirds their weight.

Small bunches of nearly dried, brown roots weighing about 25 bunches to a kilo sold retail at local markets in 1945 for about 20 to 30 centavos (about 5 or 6 cents U. S. currency) a bunch. This retail price was about \$6.25 (pesos) a kilo, or 59 cents (U. S. currency) a pound.

The main use is as a sort of spice, because of the property of the root to make the mouth and tongue numb and burn when minute pieces are chewed. The roots are used, like chile, to flavor beans and other foods and to strengthen alcoholic drinks.

It was reported that an extract of the root is used for colds and pneumonia. The root is chewed to relieve toothache. However, there is danger of choking if too much is eaten, and deaths have been reported from this cause.

A small quantity of chilcuague roots is shipped to Mexico City for use in making a local insecticide. The ground root put in a dish of milk has been employed also to kill flies drinking the milk. It is said that larvae of warble flies in the skin of cattle may be killed by putting powdered root in the wound. In the United States use of chilcuague roots in insecticides has been confined to experiments by the Bureau of Entomology and Plant Quarantine.

Possibly medicinal or other uses may be discovered. An alcoholic extract of the root has been tested successfully by dentists as an anesthetic in the extraction of teeth.

PROPAGATION

Preliminary tests of propagating *Heliopsis longipes* were made in Mexico in 1945. If this species should become important commercially, cultivation would be necessary because of the rather limited and poorly accessible supply of the rare wild plants. At four localities with elevations from about 1,800 to 2,400 meters, wild plants were transplanted successfully in rows and beds on a small scale. The plants were dug with picks, most of the tops were cut off, and the roots were trimmed. However, where it was necessary to retain the plants up to a week before transplanting, even though kept moist, survival was low. In spite of the succulent character of the roots, ordinary care must be used in transplanting. When exposed to the air the succulent roots dry out rapidly and shrivel within a week. In tests, cut fleshy roots planted in the ground did not grow, though they remained fleshy as long as a month or more before dying. The marketed dried roots with bases of stems attached will not grow. As the rhizomes sprout readily at the nodes, propagation by rhizome cuttings might be successful. Doubtless chilcuague could be propagated commercially by seeds also, though there was no opportunity to test this method. Roots of suitable size and quantity for harvest should be ready within 2 or 3 years after planting.

Under care, transplants grew better than wild plants. One small plant with a few short stems about 5 cm long in a block of soil 15 cm square and 10 cm thick was transplanted in Mexico City on June 8. It grew rapidly and opened its first flower head on July 21. By July 30, 5 flower heads were open, and by the end of August there were 10 open heads and about 10 more flower buds. More than 40 flower heads had matured by October 5, when 2 flower heads were still open.

SUMMARY

"Chilcuague," a Mexican herbaceous plant species of possible commercial value as a source of insecticide and previously designated as "*Erigeron affinis*," has been identified as *Heliopsis longipes* (A. Gray) Blake (family Compositae). This species of restricted geographic distribution was known botanically from only two collections in southern San Luis Potosí but now has been found also in northeastern Guanajuato and has been reported from northern Querétaro. In Guanajuato it is rare and scattered in forests of *Quercus* spp. at about 1,825 to 2,250 meters in altitude. The fleshy roots, which produce a strong numbing, burning sensation in the mouth when chewed, are used locally as a spice and are the source of the insecticidal principle. Because of the limited occurrence, cultivation would be necessary to supply commercial quantities of the roots. Wild plants were transplanted successfully on a small scale.

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ENTOMOLOGY.—*New species of* Metachroma *and other chrysomelid beetles from the West Indies.*[1] Doris H. Blake, Arlington, Va.

This paper contains the description of six new black or dark metallic colored species of *Metachroma* Dejean, a small pale species of *Aphthona* Dejean, and the second species of *Megasus* Jacoby to be described, all of which are from the West Indies.

Megasus semivittatus, n. sp.

Fig. 1

Length 3 mm, faintly shining, pale yellow-brown with a dark median spot extending from occiput down front of head, a dark stripe on each side of prothorax bordering on the explanate margin and a stripe along the sides of the elytra, a short sutural vitta at base and another interrupted one at the middle; also running diagonally across each elytron from apex to humerus a faint orange band. Basal sulcus on prothorax not very distinct and not limited at the ends. Antennae as long as beetle.

Head with interocular space a little more than half its width; occiput smooth, impunctate, a broad median dark stripe extending to above tubercles; tubercles faintly marked, without median groove, bulging slightly over antennal sockets; a fovea on each side near eye. Below antennal sockets on each side a shallow excavation divided in the middle by a narrow, slightly produced carina. Antennae as long as body, joints 2 and 3 short, joints 4–7 long, remainder a little shorter; the basal joints pale, apices of joints 4–11 slightly darker. Prothorax approximately twice as broad as long, with slightly rounded sides, obtuse anteriorly and a sharp tooth at basal angle; a very indistinct and shallow basal groove, not limited at the ends by a longitudinal fovea; surface impunctate, pale, with a dark stripe along the side next to the explanate margin. Elytra a little broader than prothorax and also with a dark stripe along the side extending to the suture at the apex, and at base extending around and down suture but not to the middle, also a short interrupted median stripe at base and middle, and a faint orange diagonal stripe across the elytron; surface impunctate and faintly shining. Body beneath pale, with paler legs. Anterior coxal cavities open, hind femora enlarged, hind tibiae slightly grooved, a short spur at the tip, first tarsal joint long, claws appendiculate. Length 3 mm, width 1.3 mm.

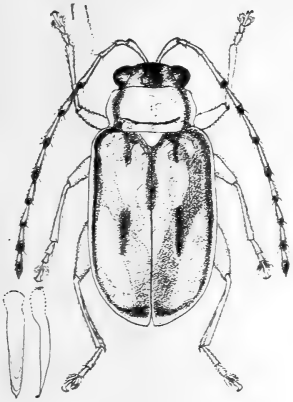
Type male, U.S.N.M. no. 58777,

Type locality.—Mandeville, Jamaica, collected by Van Duzee in April 1906 (from the Wickham collection).

Remarks.—The genus *Megasus* was described by Jacoby[2] to accommodate a beetle from Gua-

[1] Received April 21, 1948.

[2] Jacoby, Biologia Centrali-Americana, Coleoptera, 6(pt. 1): 321. 1884.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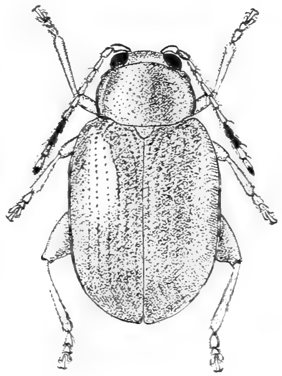
2. Metachroma schwarzi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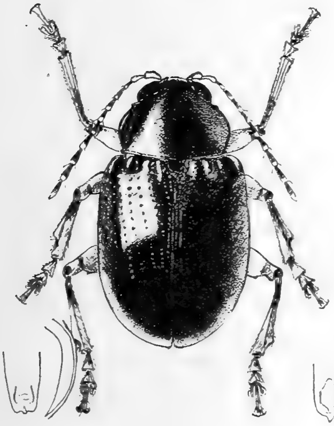
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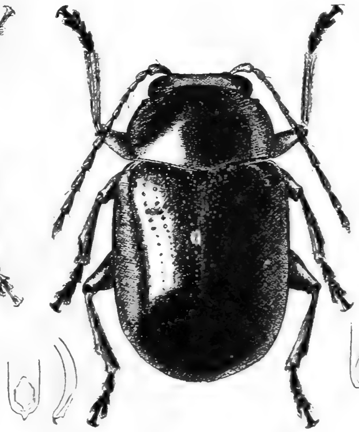
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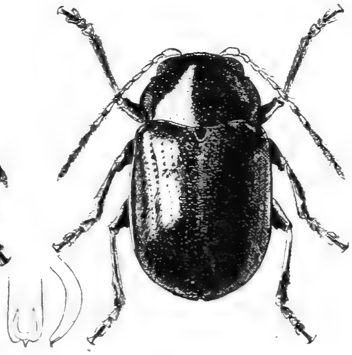
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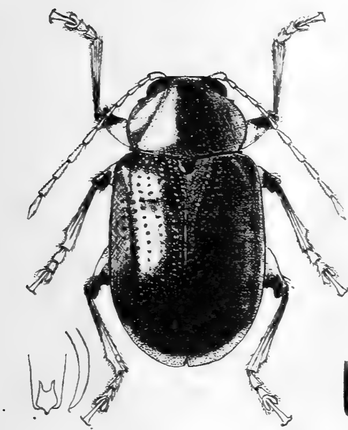
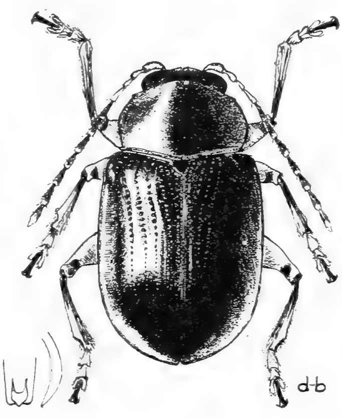

7. Metachroma felis


8. Metachroma longitarsum (dark form)



9. Metachroma flavolimbatum

Figs. 1–9.—New West Indian Chrysomelidae.

temala that did not quite fit into the genus *Lactica* because of its very long antennae and the thoracic groove, which was not limited at the ends by a longitudinal fovea. This second species closely corresponds with *Megasus bimaculatus* in all but marks of coloration. The strikingly long antennae, the head with its poorly developed frontal tubercles and closely set antennae, the transverse thorax with its obtuse anterior angles, and with the basal groove in this species rather more indistinct than in *bimaculatus* and without limiting side fovea, the large scutellum, the legs with the hind tibiae grooved and with a spur at the end, the appendiculate claws, the open anterior coxal cavities, all fit into this genus erected by Jacoby. I have compared the beetle with a specimen labeled by Jacoby as *M. bimaculatus* in the Bowditch collection at Cambridge.

Aphthona elachia, n. sp.

Fig. 3

About 1.3 mm. in length, ovate, shining pale yellow-brown, eighth and ninth antennal joints dark; thorax finely punctate, elytral striae fine and disappearing before the apex.

Head polished, a short sulcus on each side of front, interantennal carina narrow, slightly produced, interocular space about half width of head. Antennae not reaching the middle of the elytra, pale yellow with eighth and ninth joints and tip of last black. Prothorax not quite twice as broad as long, moderately convex with rounded sides and obliquely cut anterior angles, basal margin at sides obtusely angulate; surface shining, finely and shallowly punctate. Elytra broad and somewhat convex, shining, striate punctures fine and becoming indistinct at apex. Body beneath pale, shining, lightly pubescent. Length 1.3–1.4 mm; width 0.7 mm.

Type female and one female paratype, M.C.Z. type no. 27828.

Type locality.—Morne Trou d'Eau, Haiti, collected by P. J. Darlington, November 19, 1934. Other locality: Port-au-Prince, Haiti, collected by P. J. Darlington, October 6, 1934.

Remarks.—This is a smaller, paler, less convex species than *A. fraterna* Blake and has only the eighth and ninth and tip of the last joint of the antennae dark; in that species joints 6–9 are dark.

Metachroma schwarzi, n. sp.

Fig. 2

About 4.5 mm in length, oblong, shining black with reddish-brown mouthparts, antennae, and tarsi; elytral striae distinct to the apex.

Head with interocular space about half its width, shining above, alutaceous in lower front, densely punctate, no distinct transverse line between antennal sockets, groove about inner side of eye distinct. Antennae not extending halfway down the elytra, deep reddish brown, of the usual proportions. Prothorax not twice as wide as long, with arcuate sides and a small tooth at apical and basal angles, an impressed line along basal margin and behind the eyes on the anterior margin; surface polished, finely punctate. Elytra entirely dark, shining, a very slight lateral depression below the humerus, striate punctures coarse and distinct to the apex and rather deeply impressed. Epipleura distinct almost to the apex. Body beneath shining, piceous with the tip of the abdomen a little paler, legs dark with pale tarsi, a tiny tooth on hind femora. Length 4.4–4.5 mm; width 2.5 mm.

Type female, U.S.N.M. no. 58778, and one female paratype in M.C.Z.

Type locality.—Cayamas, Santa Clara Province, Cuba, collected by E. A. Schwarz.

Remarks.—Dr. Schwarz himself labeled this as a new species. It strongly resembles *M. adustum* Suffrian but has entirely black elytra and black legs. The elytral punctation is coarser and distinct to the apex and the eyes are smaller and more widely set.

There is a series of seven specimens taken by Darlington at Soledad (Cienfuegos), Cuba, in 1929 and 1936 that also have entirely dark elytra, but which are clearly very closely related to *M. adustum,* if not a color variety. They seem a little less deeply and coarsely striate-punctate than *M. adustum,* and the tip of the aedeagus is a little thinner. Whether this is a subspecies of *adustum* Suffrian or merely a color form is not clear.

Metachroma felis, n. sp.

Fig. 7

About 5 mm in length, oblong, shining black with pale antennae, legs, and elytral apex.

Head with interocular space less than half the width, shining on occiput and front, more alutaceous on lower front, densely punctate, no distinct transverse line between antennal sockets, a slight, short, median vertical groove and the usual groove around eye, labrum and mouthparts reddish or yellowish brown. Antennae pale, extending about to the middle of the elytra, of the usual proportions. Prothorax not twice as wide as long with arcuate sides and a small tooth at each corner, and an impressed line along the sides and basal margin and up behind the eyes on anterior margin; surface polished, with obsolete and moderately dense punctation. Elytra very shining, rows of punctures distinct in basal half but becoming indistinct after the middle and vanishing at the apex, the striate punctures on the sides regular but short. Elytra entirely dark except for a narrow strip along the apex. Epipleura vanishing shortly before the apex. Body beneath deep brown, shining, legs pale with the narrowed apex of femora dark and a dark streak down the tibiae. Hind femora with a small tooth. Length 4.7–5.5 mm; width 2.5–3 mm.

Type male and one female paratype, M.C.Z. type no. 27827.

Type locality.—Arthurstown, Cat Island, Bahamas, collected July 23, 1935, by W. J. Clench.

Remarks.—This is one of the species very closely related to *M. adustum* Suffrian. It differs from the others in having only a narrow pale apex to the elytra and no pale area along the sides or on the humeri, which are usually pale in the Florida and Cuban beetles. It is also slightly larger than either of them, and the tip of the aedeagus is broader than that of *M. adustum* and more like that of *M. terminale* Horn. The elytral striae are not so impressed as in the other closely related species. There is one specimen, a female, in the National Museum collection from Eleuthera, Bahamas, collected in July by H. F. Wickham, that seems to be the same species.

A single specimen, a female, from Constanza, Dominican Republic, elevation 3000–4000 feet, collected in August 1938 by P. J. Darlington, represents another closely allied species or subspecies. In this specimen the head is more polished and finely punctate, the punctures of the elytral striae are not so dense, and the pale area on the elytra extends broadly along the sides and at the apex. This single specimen, however, does not present such distinct differences as occur in *M. schwarzi* and *felis.*

Metachroma flavolimbatum, n. sp.

Fig. 9

About 5 mm in length, oblong, shining piceous with head in part, basal antennal joints, anterior margin of prothorax, margin of elytra and legs reddish, femora banded near apex.

Head with interocular space less than half its width, no distinct line between clypeus and front, a median depression on front, the usual groove around eye; surface alutaceous and rather densely and obsoletely punctate, the occiput and a median area down front piceous, rest reddish brown, jaws piceous. Antennae extending to the middle of the elytra, second and third joints subequal, remainder longer and with only apices pale. Prothorax not twice as broad as long with arcuate sides and a small tooth at basal and anterior angles, an impressed line along basal margin and on sides of anterior margin behind the eyes; surface very finely and obsoletely punctate, mostly shining piceous but reddish brown anteriorly. Elytra with small humeri and a slight basal callosity and depression below it, striate punctures deeply impressed and dense, becoming finer and shallower in apical half, in short, regular rows on sides; shining piceous with the sides from humerus to apex pale, the pale area wider at apex. Body beneath reddish brown, shining, almost glabrous, legs pale yellow with a dark band around narrowed part of femora and a dark streak down tibiae; hind femora with a faint trace of tooth. Length 5 mm.; width 2.8 mm.

Type male U.S.N.M. no. 58779.

Type locality.—Mess Castle near Antully, St. Thomas Parish, Jamaica, collected November 5, 1928, by C. R. Orcutt.

Remarks.—This is another of the *adustum* group of species. It is slightly larger than *adustum,* and the aedeagus has a shorter point to the tip. Unlike most of the species in the *adustum* group it has the antennae mostly dark.

Metachroma piceum, n. sp.
Fig. 4

About 4.5 mm in length, ovate, shining, deep reddish brown to piceous with pale legs, the femora banded at the narrowed apex, tibiae in part darkened, elytra with paler streaks along the basal margin and on humeri and pale along the sides at the apex, base of antennal joints 3–11 dark. All femora mucronate.

Head with interocular space about half its width, rounded over occiput with broad front having a short median depression between the nearly obsolete frontal tubercles; dark piceous with a reddish-brown area on each side of front, lower front and labrum also reddish; surface dull and alutaceous with fine, shallow punctures. Antennae not reaching the middle of the elytra, third joint shorter than fourth, basal joints pale reddish and joints 3–11 darker at the base. Prothorax wider than long with arcuate sides, a small tooth at each corner and an impressed line along basal margin and behind the eyes on anterior margin; surface polished, very minutely punctate; piceous with deep reddish brown streaks along anterior and basal margins, possibly in pale specimens only a piceous transverse band. Elytra striately punctate, the punctures coarsest in transverse depression below basal callosity, becoming fine at apex; shining deep piceous with reddish brown streaks along short raised basal costae and on humeri and a pale margin along the apex, and partly along the sides. Epipleura disappearing before the apex. Body beneath deep reddish brown with tip of abdomen and legs paler, femora near apex banded and tibiae with deeper shading in basal half, all femora with a small tooth, tibiae ridged and emarginate in two hind pairs, claw joint very long. Length 4.4–4.6 mm; width 2.6 mm.

Type male, M.C.Z. type no. 27824; one paratype.

Type locality.—Main Range, Blue Mountains, 5,000–7,388 feet elevation, Jamaica, collected August 17–19, 1934, by P. J. Darlington; paratype collected at Whitfield Hall, Blue Mountains, near 4,500 feet elevation, Jamaica, August 13–20, 1934, by P. J. Darlington.

Remarks.—Although the pale coloration at the apex of the elytra is suggestive of beetles of the *M. adustum* alliance, *M. piceum* does not belong to that group, being more oval and with reddish-brown markings and with more widely set eyes.

Metachroma longitarsum Blake
(dark color form)
Fig. 8

Metachroma longitarsum Blake, Journn. Washington Acad. Sci. **36**: 24. 1946.

A dark color form of this species, represented by three black specimens not associated with the pale reddish-brown spotted female in the original working up of the material, has come to my notice. Except for the dark color these three specimens agree in every way with the pale spotted form, having similar size, shape, and punctation, and furthermore they were collected at the same time and place. They are entirely dark except for the mouthparts, frontal tubercles in part, antennae, and tarsi.

Metachroma nigroviride, n. sp.
Fig. 6

From 4 to 4.5 mm in length, broadly oblong, shining, deep reddish brown to dark metallic green with reddish antennae and legs varying from reddish brown to metallic green, prothorax lightly punctate; elytral striate punctures becoming very fine at apex.

Head with interocular space about half its width, smoothly rounded over occiput and down front, no distinct transverse sulcus between antennal sockets, a faint median vertical line down front in some specimens, the usual groove about inner side of eye; finely and obsoletely punctate, more distinctly in lower front. Antennae reaching about to the middle of the elytra, reddish, the distal joints tending to be darker. Prothorax not quite twice as wide as long, smoothly convex, with arcuate sides and a small tooth at apical and basal angles, surface polished, finely and not densly punctate. Scutellum polished. Elytra with a slight basal callosity, well-marked humeri, and a short intrahumeral depression and slight transverse depression below basal callosity; rows of striate punctures distinct but not very coarse and becoming finer towards apex; epipleura disappearing shortly before apex. Body beneath deep reddish brown to piceous, shining, lightly pubescent, hind femora with a small tooth, tibiae ridged and in middle and posterior pair emarginate near apex. Length 4–4.5 mm; width 2.5–2.6 mm.

Type male, M.C.Z. type no. 27825; 6 paratypes, 1 paratype (no. 58781) in U. S. National Museum.

Type locality.—Puerto Plata, Dominican Republic, collected by Hurst. Other localities: Villa Altagracia, collected in July 1938 by P. J. Darlington; Constanza, elevation 3,000–4,000 feet, collected in August 1938 by P. J. Darlington, both in Dominican Republic.

Remarks.—Three of the eight specimens examined are deep reddish brown without trace of the metallic green of the others. Possibly these are immature specimens.

Metachroma hottense, n. sp.

Fig. 5

About 3 mm in length, broadly oblong, polished dark metallic green with dark brown mouthparts, antennae, legs, and undersurface; head and thorax impunctate, striate punctures on elytra coarsest below basal callosity, on sides and at apex becoming indistinct.

Head with interocular space more than half its width, front broad, flat, impunctate, no transverse groove between antennal sockets; the usual groove running up on inner side of eye. Labrum reddish brown. Antennae scarcely reaching the middle of the elytra, five basal joints reddish, distal joints deep piceous, joints 2–4 subequal and shorter than the remainder. Prothorax not twice as broad as long, moderately convex, with arcuate sides and small tooth at each angle, surface polished, impunctate, basal margin lightly sinuate, an impressed line along it and behind the eyes on anterior margin. Elytra a little broader than prothorax with a short intrahumeral sulcus and a transverse depression below basal callosity, the striate punctures in this coarser than elsewhere, at sides and apex becoming rather indistinct; surface polished. Epipleura disappearing shortly before apex; body beneath dark, shining, lightly pubescent, femora not toothed, tibiae ridged; middle and hind tibiae emarginate near apex. Length 3.2 mm; width 2 mm.

Type male, M.C.Z. type no. 27826.

Type locality.—Desbarriere, Morne La Hotte, Haiti, near 4,000 feet, collected October 12–14, 1934, by P. J. Darlington.

Remarks.—This beetle is considerably smaller than *M. nigroviride* and the thorax differs in not being punctate at all.

ORNITHOLOGY.—*The races of the red-whiskered bulbul,* Pycnonotus jocosus (*Linnaeus*).[1] H. G. DEIGNAN, U. S. National Museum.

The red-whiskered bulbuls may be conveniently divided into two main groups, in one of which adults have the red feathers of the infraocular tuft long and brighter, while in the other they have them short and darker. To the first category belong only *fuscicaudatus*, *abuensis*, *pyrrhotis*, *emeria*, and *peguensis*. A tentative arrangement of the races, with descriptions of two new forms, is offered below.

For the privilege of examining their series of this species, my thanks are hereby tendered to the authorities of the American Museum of Natural History and of the Academy of Natural Sciences of Philadelphia.

1. **Pycnonotus jocosus fuscicaudatus** (Gould)

Otocompsa fuscicaudata Gould, Proc. Zool. Soc. London, for 1865, pt. 3: 664. March 1866 ("The southern portion of the peninsula of India . . . very common in many parts of the Madras Presidency"; type locality restricted to the Nilgiri Hills, Nilgiri Hills District, Madras Presidency, by Whistler and Kinnear, Journ. Bombay Nat. Hist. Soc. **35**: 756. July 15, 1932).

Range.—Western India, from the Tapti River south to Cape Comorin and the Salem District of the Madras Presidency.

2. **Pycnonotus jocosus abuensis** (Whistler)

Otocompsa jocosa abuensis Whistler, Bull. Brit. Orn. Club **52**: 40. Dec. 1, 1931 (Mount Abu, Abu District, Sirohi State, South Rajputana Agency, India).

Range.—Southeastern Rajputana.

Remarks.—This race and the precedent one differ from all others in the absence of conspicuous white tips from the outer tail feathers.

3. **Pycnonotus jocosus pyrrhotis** (Hodgson)

[*Ixos*] *pyrrhotis* Hodgson, *in* J. E. Gray, Zoological Miscellany, No. 3: 84. "June" 1844 (Nepal).
Ixos jocosus v[el]. *pyrrhotis* "Hodgs." J. E. Gray,

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 16, 1948.

Catalogue of the specimens and drawings of Mammalia and birds of Nepal and Thibet: 89. 1846 (Nepal).

I [*xos*]. *pyrrhotis* "Hodgs." Bonaparte, Conspectus generum avium **1**: 265, 1850 (India; type locality here corrected to Nepal, *ex* Hodgson).

Otocompsa jocosa provincialis Whistler, Bull. Brit. Orn. Club **52**: 40. Dec. 1, 1931 ("Kumaon Bhabar," United Provinces, India).

Range.—The Valley of Nepal, and northern India from the eastern Punjab to Bihar.

Remarks.—Under [*Ixos*] *pyrrhotis* Hodgson, 1844, we find "*I. jocosus*? v[el]. *pyrrhotis*, 209." This seems by the narrowest margin to validate the name from 1844; if, however, the reference is rejected, it seems certain that, by analogy with Opinion 53 of the International Commission on Zoological Nomenclature, the name must be taken from J. E. Gray, 1846. The first proper description attached to *pyrrhotis* was given by Bonaparte in 1850.

4. **Pycnonotus jocosus emeria** (Linnaeus)

[*Motacilla*] *Emeria* Linnaeus, Systema naturae, ed. 10, **1**: 187. 1758 (Bengal).

[*Lanius*] *Emeria* Linnaeus, Systema naturae, ed. 12, **1**: 137. 1766 (Bengal).

[*Muscicapa*] *Emeria* Linnaeus, Systema naturae, ed. 12, **1**: 326. 1766 (Bengal).

Haematornis erythrotis "Swains." J. E. Gray, Catalogue of the specimens and drawings of Mammalia and birds of Nepal and Thibet: 89. 1846. *Nomen nudum!*

I[*xos*]. *erythrotis* "Bp. ex Sw. Mus. Lugd." Bonaparte, Conspectus generum avium **1**: 265. 1850 (Java, error; type locality here corrected to Calcutta, Bengal Province, India).

Range.—Lowlands of eastern India from Madras to Calcutta and possibly farther.

Remarks.—The name *erythrotis* was, at its first appearance, a *nomen nudum*, treated as a synonym of "*jocosus*" of J. E. Gray (not the true *jocosus* of Linnaeus), which equals *pyrrhotis* of Hodgson. Since the specimen upon which Swainson based his MS. name is the same as served for type to Bonaparte and is, according to information courteously furnished me by Dr. G. C. A. Junge, almost certainly an example of *emeria*, I feel justified in sinking the name in synonymy with *emeria* rather than with *pyrrhotis*.

Chasen (Handlist of Malaysian Birds: 204. 1935) altered the type locality of *I*[*xos*]. *erythrotis* Bonaparte from Java to Tavoy, Tavoy District, Tenasserim Division, Burma, but Dr. Junge's examination of the type specimen has shown that this "correction" can not stand.

5. **Pycnonotus jocosus peguensis** (Stuart Baker)

Otocompsa emeria peguensis Stuart Baker, Fauna of British India, Birds, ed. 2, **1**: 396. Aug. 16, 1922 (Pegu Division, Burma, by implication, and so stated by Stuart Baker, Fauna of British India, Birds, ed. 2, **7**: 81. May 14, 1930; type locality here restricted to Rangoon, Rangoon Town District, Pegu Division, Burma).

Range.—Lower Burma from Arakan (Sandoway District) to Tenasserim (Thaton District).

Remarks.—The range given for this form at the original description was "South Chin Hills and South Kachin Hills to Tenasserim, Arrakan and the whole of the Central Hills of Burma, Siam and Shan States. Andamans and Nicobars." My material indicates that no less than four races divide this territory among themselves, of which one, the bird of Pegu, differs strikingly from the other three on its bright, elongated infraocular tufts.

Although I have accepted *peguensis* as a valid subspecies here, I am not at all convinced that this name should not be synonymized with *emeria*.

6. **Pycnonotus jocosus whistleri**, n. subsp.

Type.—U. S. N. M. no. 178729, adult male, collected at the Cinque Islands (southeast of Rutland Island), Andaman Islands, Bay of Bengal, on January 18, 1901, by William L. Abbott.

Diagnosis.—Nearest *P. j. peguensis* in the brownish tone of the upperparts, but easily separable from that race by having the feathers of the infraocular tuft distinctly shorter and usually darker, and by having the bill, sex for sex, decidedly longer and more robust.

Range.—Andaman Islands; Nicobar Islands (introduced, *fide* Davison, *in* Hume, Stray Feathers **2**: 225. 1874).

Remarks.—Thirteen winter-taken specimens of *P. j. whistleri* have been compared with 5 similar examples of *P. j. peguensis* and 29 of the Malayo-Siamese race. For distinctions between the last-mentioned and *whistleri*, see below.

7. **Pycnonotus jocosus pattani,** n. subsp.

Type.—U. S. N. M. no. 330406, adult male, collected at Pattani (lat. 6°50′ N., long. 101°-15′ E.), Pattani Province, southernmost Siam, on January 26, 1931, by Hugh M. Smith (original number 4479).

Diagnosis.—Nearest *P. j. fuscicaudatus* in the cold grayish-brown tone of the upperparts, but immediately separable from that race by having the feathers of the infraocular tuft short and dark and the majority of the rectrices conspicuously tipped with white.

From *P. j. whistleri* distinguished by having the brown of the upperparts paler and grayer, and by having the bill, sex for sex, shorter and less robust.

From *P. j. monticola* easily separated by having the brown of the upperparts much paler and grayer.

Range.—Indochine south of central Annam and Haut-Laos, all Siam, and Malaya south to Penang Island and Kelantan State.

Remarks.—I can find no character by which southern birds can be distinguished from more northern ones. Specimens before me from the Malay Peninsula seem to have the broken pectoral band more nearly joined across the breast, but this could easily result from their having the body less tightly stuffed with cotton.

8. **Pycnonotus jocosus monticola** (McClelland)

Ixos monticola McClelland, Proc. Zool. Soc. London, March 1840, pt. 7: 160 ("Kossia mountains," Khasi and Jaintia Hills District, Surma Valley and Hill Division, Assam Province, India).

? *Otocompsa jocosa hainanensis* Hachisuka, Orn. Soc. Japan Suppl. Publ. No. 15: 74. Oct. 30, 1939 (Nauchan, Hainan Island).

Range.—Sikkim; Bhutan; Assam; northern Burma and the Shan States; Yunnan; Indochine north of the range of *P. j. pattani.*

Remarks.—I was at first inclined to place all birds from localities between Sikkim and Hongkong under the name *jocosus*, as has been done by British ornithologists, but three Kwantung specimens have the upperparts so much paler than the rest, that for the present I shall keep them apart. McClelland's name is available for the darker populations, but it must be regretted that his type did not come from northeasternmost Assam, where the saturate coloration of the upperparts reaches its highest development.

It is extremely difficult to believe that the unique specimen of *hainanensis* is anything but an escaped cage bird. Whether Hachisuka's name should be synonymized with *monticola* or with *jocosus* cannot be decided without examination of the type.

9. **Pycnonotus jocosus jocosus** (Linnaeus)

[*Lanius*] *jocosus* Linnaeus, Systema naturae, ed. 10, **1**: 95. 1758 (China; type locality here restricted to Canton, Kwangtung Province).

Range.—Hongkong, Kwangtung, and adjacent areas of Kwangsi.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

419th MEETING OF BOARD OF MANAGERS

The 419th meeting of the Board of Managers, held in the Cosmos Club, June 7, 1948, was called to order at 8:05 P.M. by the President, Dr. FREDERICK D. ROSSINI. Others present were H. S. RAPPLEYE, H. A. REHDER, W. L. SCHMITT, W. W. DIEHL, F. M. DEFANDORF, W. N. FENTON, WALTER RAMBERG, C. E. WHITE, W. A. DAYTON, C. A. BETTS, F. B. SILSBEE, M. A. MASON, O. B. FRENCH, C. L. GAZIN, and, by invitation, FRANK THONE.

The Secretary read the following minutes of the Executive Committee:

The Executive Committee met in Dr. Rossini's office at the Bureau of Standards at 8:05 P.M. on May 26, 1948. The President, DR. F. D. ROSSINI, presided. Others present were: WALTER RAMBERG, H. S. RAPPLEYE, W. L. SCHMITT, and C. L. GAZIN.

The meeting was called to consider matters pertaining to the annual meeting, intersociety affairs, the Index to the JOURNAL, and the "Red Book."

The subject of the annual meeting in January was discussed, and it was decided to recommend to the Board of Managers that instead of the customary lecture an Academy dinner be held in conjunction with the regular business of the annual meeting.

Dr. Schmitt exhibited a page proof of the "Red Book" and announced that the cost of publication had been determined as follows: Cost of printing, slightly less than $2,000; incidental bills including typing, approximately $500; cost of cuts, a little over $900; totaling approximately $3,400. Discussion then arose as to the adequacy of 1,000 copies and it was suggested that the approximately $200 difference from the maximum of $3,600 allowed for the publication of the "Red Book" be used to print extra copies and absorb the cost of distribution. The cost of additional copies was quoted as $584 per 1,000 and about 60 cents per copy for a smaller number. Upon further discussion it was proposed that a price of $1 be charged for outside purchases but that a prepublication

price of 75 cents per copy be offered to the Affiliated Societies prior to a fixed date, up to which the printer will agree to keep the type set up. The motion was then approved that the Committee recommend to the Board of Managers that the number of copies above 1,000 to be printed be determined by the balance remaining from the original $3,600 as stated above, allowing approximately $75 for distribution costs, and increasing the number still further by whatever quantity is ordered by the Affiliated Societies during the prepublication period.

The matter of an index to the first 40 volumes of the Journal, referred to the Executive Committee by the Board at its 418th meeting, was introduced. After considerable discussion, the Executive Committee voted to recommend to the Board that it authorize, for the necessary expenses of preparing the manuscript, including the materials, a sum not to exceed $2,000, dispersable as required during the period 1949 to 1951, inclusive. It was the feeling of the Committee that outside funds might be secured for the cost of publication.

The matter of the request on the part of the Joint Committee on Press Relations that the Academy pay half of its operating expenses, referred to the Executive Committee by the Board of Managers at its 418th meeting, was introduced. The Committee decided to recommend to the Board that the Academy appropriate to Dr. Frank Thone for discharge of the Academy obligation $62.10 covering the last part of 1947 and all of 1948. The Committee then recommended that the Affiliated Societies be approached concerning the future of the Science Calendar, and if the response accounts for at least 70 percent of the annual cost, that the Academy proceed to act as a collection agency for these contributions from the Affiliated Societies, add the necessary amount from its own funds, and continue to support its share of the project.

The subject of the Science Fair for the secondary-school children was introduced and after some discussion of past arrangements and the manner of its operation in certain other cities, the Executive Committee approved the motion that a recommendation be made to the Board that the Academy appropriate $100 to forward the Science Fair in Washington for 1949, provided that the Fair is sponsored by Science Service, and provided that the necessary balance is secured from other soures.

In consideration of the matter of the Science Calendar and of the Science Fair, discussion was introduced regarding implementation of intersociety activities, and the means whereby a closer coordination might be secured with the Affiliated Societies in such matters. The Executive Committee then agreed to recommend to the Board that the president be authorized to appoint a committee of vice-presidents to study the question of providing a more effective bond between the Academy and the Affiliated Societies.

The Board of Managers considered separately the various recommendations of the Executive Committee and all were approved by vote of the Board, with the exception that, with regard to the recommendation of an annual dinner, the Board approved, providing the dinner be less than $5 per person and preferably less than $3 per person.

As a result of the discussion which ensued with respect to recommendations regarding the Joint Committee on Press Relations, the Secretary was instructed to write letters of appreciation to Mr. Darnell for his work in getting up the "Science Calendar" and to the three Washington newspapers in which it has appeared for their cooperation in its publication. The Secretary was also instructed to contact the Affiliated Societies in the fall, in an attempt to secure their cooperation in the matter of contributions to operating expenses of the Joint Committee on Press Relations, as outlined in the recommendation of the Executive Committee.

The 27 persons nominated for resident membership in the Academy at the 418th meeting were elected.

Upon recommendation of the Treasurer, Howard S. Rappleye, the following resolution was passed.

Resolved, that the Washington Academy of Sciences transmit its certificates of stock owned in the Washington Sanitary Improvement Co. to the Washington Loan and Trust Co., Transfer Agent, for reissue on the basis of two shares of new stock for each share of old stock, in accordance with the plan outlined in the letter of the Washington Sanitary Improvement Co. under date of May 27, 1948, and that Howard S. Rappleye, Treasurer, be authorized to prepare the necessary transmittal letter, deliver the certificates, and receive the new certificates when issued.

Dr. Thone, representing Science Service, recommended to the Board of Managers that the Academy extend its interests to participation in the annual Science Talent Search for the District of Columbia. Upon discussion, the Board decided that before committing the Academy to this program a committee be appointed by the President to study the general matter of encouragement of Science Talent in the schools of the Washington area, the manner in which the Academy might participate, and make recommendations to the Board.

The meeting was adjourned at 10:20 P.M.

C. Lewis Gazin, *Secretary.*

PHILOSOPHICAL SOCIETY

1286th Meeting

The 1286th meeting was held in the auditorium of the Cosmos Club, October 11, 1947, President Mohler presiding.

Program: E. U. Condon, National Bureau of Standards: *Nuclear forces.*—There was presented a general review of the present position of our knowledge with regard to the nonelectromagnetic forces of interaction between the fundamental particles of physics, electrons, protons, and neutrons. The different sources of experimental information about strength and range of such forces, such as nuclear mass defects and angular scattering data were correlated. (*Author's abstract.*)

1287th Meeting

The 1287th meeting was held in the auditorium of the Cosmos Club, October 25, 1947, President Mohler presiding.

Program: Robley C. Williams, University of Michigan: *Recent developments in electron microscopy.*—Some of the recent developments in electron microscopy during the past three years have been: (1) the successful microtomy of sections thin enough to allow 60 kv electrons to penetrate them, (2) the tissue culture of cells of sufficient thinness to allow the nucleus to be observed, (3) the "shadow-casting" of minute particulate specimens to improve the contrast between them and their substrate background, (4) the microincineration of biological specimens to afford an estimate of their ash content, (5) the improvement in substrate smoothness to allow particles of diameters less than 50A to be photographed, and (6) the beginnings of an electron lens technique to allow radioactive specimens to be photographed by means of their own beta particles.

Development (5) has particularly interested the author and his colleagues. They have found that glass is an almost perfectly smooth substrate, with maximum deviations of less than 10A from perfect smoothness. The technique most adaptable to the photography of extremely small objects appears to be to cause the objects to adhere to a cleaned glass surface, shadow-cast them with uranium sulphide, and then strip the particles and the uranium sulphide film from the glass with a thin film of collodion. (*Author's abstract.*)

1288th Meeting

The 1288th meeting was held in the auditorium of the Cosmos Club, November 8, 1947, President Mohler presiding.

Program: D. C. Ginnings, National Bureau of Standards: *The Bunsen ice calorimeter in modern heat measurements.*—There was described an improved form of a Bunsen ice calorimeter constructed for use in connection with measurements of specific heats at high temperatures (up to 1,000°C.). The ice calorimeter was investigated carefully from the standpoint of high reproducibility and high accuracy. The calibration factor of the calorimeter (from a large number of electrical calibration experiments) was established to be 270.37 ±0.06 international joules per gram of mercury. Using this factor, the density of ice at 0°C. and one atmosphere pressure was calculated to be 0.91671 ±0.00005 g/ml.

The ice calorimeter was used to measure specific heats at high temperatures by the "drop" method, that is, heating the sample in a furnace to a known temperature, dropping the sample into the calorimeter, and measuring the heat given up by the sample to the calorimeter. Measurements were made in this manner on uranium, uranium trichloride, uranium tetrachloride, aluminum oxide, p-xylene, and isopropyl alcohol. Although the resulting values of enthalpy were reproducible to about 0.02 percent, an over-all accuracy of about 0.2 percent was estimated from consideration of systematic errors such as temperature measurement, etc. (*Author's abstract.*)

A. I. Dahl, National Bureau of Standards: *Temperature measurements in gas streams.*—The temperature indicated by a thermocouple junction immersed in a stream of hot gas will not, in general, be that of the gas but will be an equilibrium temperature representing the state at which the heat transferred from the gas to the junction by convection and impact is balanced by the heat transferred from the junction to the surroundings by radiation and conduction. In applications involving temperatures above 1,000°F. and velocities up to 200–300 ft/sec, the radiation effect is generally the chief source of error.

The effect of gas velocity on temperature measurements becomes appreciable at velocities in excess of 300 ft/sec, and increases as the square of the velocity. At a gas velocity of

1,000 ft/sec, the difference between the total and the static temperature of an air stream is about 80°F. A thermocouple immersed in the stream will attain a temperature somewhere intermediate between the total and static temperatures—assuming no radiation or conduction losses.

The National Bureau of Standards is conducting a research project for the development of means of reducing and determining accurately the effects of radiation, conduction, and gas velocity on temperature measurements in large-velocity, high-temperature gas streams. (*Author's abstract.*)

1289th Meeting

The 1289th meeting was held jointly with the Washington Academy of Sciences in the auditorium of the Cosmos Club, November 20, 1947, President SCHMITT of the Academy presiding.

Program: I. I. RABI, Columbia University: *The hyperfine structure of the hydrogens and other atoms.*

1290th Meeting

The 1290th meeting was held in the auditorium of the Cosmos Club, November 22, 1947, President MOHLER presiding.

Program: J. HOWARD McMILLAN, Naval Ordnance Laboratory: *Spark shadowgraphy in hydrodynamics.*—The impact of an object on a water surface compresses the water and generates a compression wave which spreads out from the point of impact with the velocity of sound. If the wave is formed by a fast-moving sphere, the wave travels as a shock wave and has a velocity greater than the acoustic velocity. These shock waves were investigated by obtaining their spark shadowgrams. Spheres were shot vertically downward from a rifle into a tank of water $12 \times 6 \times 12$ inches with plexiglass sides. The spark was an electronically operated noninductive discharge from a condenser.

The shadowgrams have shown that when steel spheres with a velocity of 1,000 to 3,000 ft/sec strike the water a compression wave with a peak of several hundred atmospheres is generated. The distribution of pressure along the wave front can be inferred from the shadowgram. These impact waves are very strong near the center of the wave and become quite weak (acoustic) near the water surface.

A steel sphere is also set into vibration when it strikes the water. These vibrations have a frequency of nearly a megacycle per second, and a pattern of secondary shock waves appears on the shadowgram. The frequency of the waves depends on the velocity of the elastic wave in the sphere and on the sphere diameter. By shooting two spheres simultaneously, these secondary waves interfere to produce areas of diminished intensity resembling the double-slit optical diffraction pattern.

By permitting the shock waves in water to strike walls having varying acoustic impedances lower than that of water, the waves are observed to reflect with a change in phase. This change in phase also appears at glancing reflection for walls of large acoustic impedance.

If specimens of various elastic media, such as steel and rock, are placed in the water and struck with a missile, dilatation waves and Rayleigh surface waves are produced in the elastic solid. These waves pass into the water and are recorded on the shadowgram. The orientation of the wave in water permits an evaluation of the elastic-wave velocity in the solids.

Spheres shot into water at velocities of 7,000 ft/sec produced shadowgrams of supersonic travel in water, the velocity of sound in water being 5,000 ft/sec. From the refraction of the optical rays the pressure distribution around the missile and shock wave was inferred. It was observed that the pressure did not fall off monotonically in front of the sphere but showed evidence of small ripples in the pressure distribution. (*Author's abstract.*)

A. G. McNISH, National Bureau of Standards, presented an informal communication on a new theory of the origin of cosmic radiation recently proposed by Menzel and Salisbury. He pointed out that the low frequency electromagnetic radiation from the sun, hypothesized for the theory, could not produce particles of cosmic-ray energies. Particles would have limiting velocities equal to that of light and could not fall far enough in the electric field of the radiation to acquire the necessary energies. Charged particles, however, injected into an electromagnetic wave at suitable velocities would travel with the wave in accordance with the laws of motion of a charge of particle in crossed electric and magnetic fields. Such particles might acquire cosmic-ray energies, but the process could occur only in interstellar

space, not within the confines of the solar system.

1291st Meeting

The 1291st meeting, the 77th annual meeting, was held in the auditorium of the Cosmos Club, December 6, 1947, President Mohler presiding.

The report of the Treasurer, confirmed by the report of the auditing committed, showed an income from dues and interest on investments of $1,659.41 and expenditures of $1,683.22 leaving a net deficit of $23.81 on ordinary expenses. The ordinary expenses were at the rate of $3.75 per member. The total estimated assets of the Society showed a decrease of $403.01 from $16,377.43 as of December 1, 1946, to $15,974.42 as of December 1, 1947.

The joint report of the Secretaries showed an active membership of 449 as of December 1, 1947, a net gain of 90 active members during the year.

The following persons were elected to membership during the year: P. Abelson, A. B. Allen, R. A. Alpher, J. Aristei, J. M. Ashcroft, J. V. Atanasoff, W. H. Avery, T. F. Ball, L. I. Barbier, H. C. Beaman, W. G. Berl, C. L. M. Blocher, F. G. Brammer, C. W. Brown, V. A. Brown, B. H. Buckingham, S. A. Buckingham, D. S. Carder, A. C. Charters, B. F. Cheydleur, E. U. Condon, J. H. Curtiss, R. K. Dahlstrom, S. M. Darr, Bessie B. Day, J. De Launay, M. F. Distad, R. L. Dolecek, R. B. Dow, W. H. Duerig, W. R. Duryee, G. E. Falk, S. N. Foner, L. W. Fraser, R. C. Gibbs, S. Githens, M. P. Givens, J. W. Graham, D. E. Gray, J. B. Green, S. Harris, G. K. Hartman, H. M. Haylor, F. B. Haynes, R. C. Herman, H. G. Hertz, F. K. Hill, W. B. Holton, J. J. Hopkins, G. A. Hornbeck, C. R. Horner, B. M. Horton, J. J. Jensen, Myrtle R. Kellington, Evelyn M. Kennedy, R. B. Kershner, J. W. Kitchens, J. H. Kuck, C. J. Lapp, P. J. Larsen, D. P. Le Galley, A. Levine, E. S. Manson, W. H. Marshall, L. L. Marton, H. Mason, F. T. McClure, E. E. Merkel, S. J. Metzler, C. F. Meyer, H. R. Mitchell, T. F. C. Muchmore, G. C. Munro, D. Nelson, P. G. Nutting, Jr., R. M. Parke, W. Perine, B. Perkins, Jr., R. B. Petersen, H. H. Porter, J. W. Ray, Mina Rees, O. F. Ritzman, A. L. Robertson, H. M. Ryder, S. N. Samburoff, T. W. Sheppard, S. Silverman, E. F. Smellie, E. H. Smith, S. W. Smith, J. H. Sreb, C. E. Swartz, H. Tatel, G. R. Tatum, H. A. Tellman, H. A. Templin, A. L. Thomas, C. A. Truesdell, E. A. Turner, Jr., A. J. Wadman, G. V. Waldo, C. N. Warfield, F. D. Werner, R. E. Wilson, A. W. Wundheiler, C. F. Yost.

The Secretaries reported the deaths of H. G. Avers, C. A. Briggs, H. S. Roberts, George Singer, D. F. Windenburg.

Following the report of the Committee on Elections, the following officers were declared elected for the year 1948: *President*, Walter Ramberg; *Vice Presidents*, Francis E. Johnston and Frank C. Kracek; *Corresponding Secretary*, Alvin G. McNish; *Treasurer*, Archie I. Mahan; *Members-at-large of the General Committee*, A. E. Ruark and W. J. Rooney.

Program: Shirleigh Silverman, Johns Hopkins University Applied Physics Laboratory: *A cinema-spectrograph for photographing rapid spectral sequences.*—A simple spectrograph designed around a 16-mm camera was described. This spectrograph was built for the purpose of obtaining spectrograms from light sources showing transient phenomena, in particular such light sources as the new types of rocket and jet combustion engines. The study of the light emitted from an acetylene-oxygen flame as a function of time illustrated its usefulness. (*Author's abstract.*)

1292d Meeting

The 1292d meeting was held in the auditorium of the Cosmos Club, December 20, 1947, President Ramberg presiding.

Program: J. B. Green, Naval Ordnance Laboratory: *The spectra of atoms.*—During the past 50 years, the spectra of atoms have furnished the most fruitful sources of information regarding the structure of atoms. Even before the isolation of the electron, the discovery of the Zeeman effect and its explanation by Lorentz gave the physicist a measure of the ratio e/m.

The very rapid developments in the theory of atomic spectra, beginning with Bohr's explanation of the spectrum of hydrogen on the basis of the Rutherford atom, and the similarities and dissimilarities of this spectrum with those of other atoms illustrate the correlation of spectra and atomic structure.

The work of Hund on complex spectra showed

how the entire electron configuration was necessary to define the problem. The variations in parameters which determine the coupling coefficients among the electrons can be determined theoretically, and measurements of the Zeeman effect can be used to verify the calculations.

The study of hyperfine structure and its Zeeman effect gave us the first clue that the nucleus of the atom had an intrinsic spin, just as the study of fine structure led to the first evidence of intrinsic spin of the electron.

The ionization potentials of atoms were among the first successes of early theory. It is recommended that the investigation of broad lines excited by atoms in states with sufficient energy to cause auto-ionization be undertaken as a matter of immediate interest in the development of the theory.

During the war great advances in the development of near infrared sensitive materials has given us a powerful tool for the study of atomic spectra in a region which has hitherto been practically unexplored. (*Author's abstract.*)

1293d Meeting

The 1293d meeting was held in the auditorium of the Cosmos Club, January 17, 1948, President Ramberg presiding.

The retiring president, Fred L. Mohler, National Bureau of Standards, delivered his presidential address on the subject *Mass spectra of hydrocarbons.* This address was published in this Journal **38:** 193–199. 1948.

1294th Meeting

The 1294th meeting was held in the auditorium of the Cosmos Club, January 31, 1948, Vice President Johnston presiding.

Program: Alvin G. McNish, National Bureau of Standards; *Radio observations of meteor trails.*—Observations of radio echoes from meteor trails by various investigators were summarized. It was then explained how ionization produced by the impact of meteors on the upper atmosphere affords a means for studying processes of recombination, diffusion, and attachment of electrons in the ionosphere. (*Secretary's abstract.*)

1295th Meeting

The 1295th meeting was held in the auditorium of the Cosmos Club, February 14, 1948, President Ramberg presiding.

Program: Frederick Seitz, Carnegie Institute of Technology: *The theory of plastic flow in solids.*—The high degree of plasticity exhibited by single crystals of metals and close-packed salts presents a fore-front problem of the physics of solids. Elementary reasoning shows that this plasticity must be associated with the presence of lattice imperfections which either exist or can be induced with ease in even the most perfect and pure crystals which are available at the present time. It was suggested by Taylor and Orowan in the last decade that these imperfections are lattice dislocations of the type first introduced by Prandtl to explain internal damping in metals. The theory surrounding dislocations has gradually evolved since it was first proposed, important developments being introduced by Burgers during the early years of the recent war. The relationship between the theory of dislocations and the observed phenomena of plastic flow in single crystals of metals is surveyed in a manner that places particular emphasis upon some of the most recent developments. (*Author's abstract.*)

A. G. McNish presented an informal communication describing the peculiar behavior of the F_2-layer in the ionosphere over regions of the earth's magnetic equator.

1296th Meeting

The 1296th meeting was held in the auditorium of the Cosmos Club, February 28, 1948, President Ramberg presiding.

Program: John Strong, Johns Hopkins University: *An extension of the application of evaporated films.*—In this illustrated lecture the extension of the applications of aluminizing the astronomical mirrors was traced from its beginnings, when amateur Philip S. Fogg's 6-inch reflector was aluminized in January 1931, to its culmination in the aluminization of the 200-inch Palomar reflector in November 1947. The first metal tank used to coat mirrors to 12-inch diameters was shown by lantern slides. The speaker, together with Dr. Enrique Gaviola, of the Observatory of Córdoba, used this tank to develop methods of parabolizing spheric mirrors, and of correcting the figure of imperfect reflectors, by the deposition of suitably non-uniform aluminum films. The 40-inch aluminizing tank was illustrated in which the mirrors of Dr. Hale's observatory and many mirrors of the Mount Wilson Observatory were coated. The use of this equipment culminated in the

aluminizing of the Crossley reflector of the Lick Observatory in December 1933. The 108-inch aluminizing tank used for coating the 60-inch and 100-inch telescope mirrors of Mount Wilson Observatory in February 1935 was illustrated. Finally Mr. Porter's excellent drawings of the new Palomar telescope were projected together with photographs of the aluminized 200-inch mirror. Various details of these large scale operations were discussed. (*Author's abstract.*)

In an informal communication, Michael Goldberg, Navy Department, exhibited several models of surfaces resembling ellipsoids of large eccentricities which share with the sphere the property of being rotatable through all possible orientations in space while remaining in contact with the four faces of a regular tetrahedron. The equations of the surfaces and a mathematical demonstration of their unusual property were shown.

A second informal communication was presented by Lloyd Jones, Naval Gun Factory, on the use of certain misleading notations in vector analysis.

1297th Meeting

The 1297th meeting was held in the auditorium of the Cosmos Club, March 13, 1948, President Ramberg presiding.

Program: John C. Hubbard,[1] Catholic University of America: *Ultrasonic propagation and its measurement.*—The application of ultrasonics during the late war to testing and location of faults in materials, the finding and continuous recording of depths in the sea, and the measurement of position and velocity of enemy ships, particularly submarines, has raised the subject to a level of popular appreciation and official support little dreamed of at the outbreak of hostilities. The great importance of the subject as compared with audible sound lies in the range of wave lengths which, in general, are small compared even with the dimensions or ordinary tools or apparatus. The recent development at the University of Virginia of electric sparks of extremely short duration has made it possible to photograph progressive ultrasonic waves,[2] showing clearly the effects of diffraction and interference, the spacing of waves in a transparent medium, and the attenuation and change of form of the waves as they progress through the medium. All the experience in this field emphasizes the making of measurements, where accuracy is required, at the lowest possible level of intensity. The application of ultrasonics to the study of elastic and viscous properties of liquids and amorphous and crystalline solids was discussed briefly and the usefulness to the physicist and chemist of ultrasonic data of great precision was shown by means of a number of illustrative examples.

[1] Assisted by the Office of Naval Research.

[2] J. C. Hubbard, I. F. Zartman, and C. R. Larkin, *Journ. Opt. Soc. Amer.* **37**: 832–836. 1947.

1298th Meeting

The 1298th meeting was the occasion of the Seventeenth Joseph Henry Lecture and was held in the auditorium of the United States National Museum, March 27, 1948, President Ramberg presiding.

Program: Robert B. Brode, University of California: *Cosmic-ray mesotrons.* This address will be published in full in this Journal.

1299th Meeting

The 1299th meeting was held in the auditorium of the Cosmos Club, April 10, 1948, President Ramberg presiding.

Program: F. Zernicke, Johns Hopkins University: *Tolerances in lens errors.*

Special Joint Meeting with the Washington Academy of Sciences

This meeting was held in the auditorium of the Cosmos Club, April 15, 1948, President Ramberg presiding.

Program: Philipp Frank, Harvard University: *Philosophical interpretations of physical theories.*

1300th Meeting

The 1300th meeting was held in the auditorium of the Cosmos Club, April 12, 1948, President Ramberg presiding.

Program: Col. Leslie E. Simon, Aberdeen Proving Ground: *Organization and Administration of German research in World War II.*—The physical conditions for German research in World War II, with emphasis on the most successful kind of research, i.e., for the Air Force, were first discussed. Inasmuch as nearly all research during that time was war research, research agencies sought to identify themselves with the armed services; this, combined with competition between government offices for

research services, caused considerable confusion in the over-all organization for research.

In order to appraise the German effort, the logical flow of contributions to new articles was next discussed. Three defects in the German system appear. First, organizations responsible for development and manufacture did not take research into their confidence. Secondly, research received too little over-all supervision, resulting in unwise duplication. Thirdly, research failed to establish communication with military plans and trends. Therefore, most new articles originated in the design state which was based on past research and were independent of contemporary research. Hence, an enormous amount of research was unremunerative in this respect.

Study of Germany's war research demonstrates that we can not continue to rely on results of past research. It is the duty of industries and government to support currently reasonable amounts of basic research. (*Author's abstract.*)

1301st Meeting

The 1301st meeting was held in the auditorium of the Cosmos Club, May 8, 1948, President RAMBERG presiding.

Program: O. S. DUFFENDACK, Philips Laboratories, Inc.: *Magnetic ferrites.*—Although it was known that certain ferrites have magnetic properties, systematic investigation by Snoek, Verwey, and their co-workers at the Research Laboratories of the Philips Company at Eindhoven, Holland, resulted in the development of magnetic ferrites having desirable characteristics for use as cores of transformers and inductance coils. These ferrites, under the tradename "Ferroxcube," are of different types for different applications, but they are all characterized by high resistivities resulting in low eddy current losses without the necessity of laminating the cores. The hysteresis losses of these materials are low also and special types of "Ferroxcube" have considerable permeability at frequencies in the megacycle range.

Typical characteristics of "Ferroxcube III," which is now in limited production in Eindhoven, are:

Initial permeability u_0 1,000 to 1,500.

Losses, at 60 kc tan δ/u (9.08 to 0.12) $\times 10^{-4}$.

Hysteresis coefficient, at 2 kc (2 to 5) $\times 10^{-6}$. (*Author's abstract.*)

H. M. O'BRYAN, Research and Development Board, presented an informal communication in which he demonstrated a special Perot-Fabry interferometer.

1302d Meeting

The 1302d meeting was held in the auditorium of the Cosmos Club, May 22, 1948, President RAMBERG presiding.

Program: RALPH E. ALPHER, Johns Hopkins University Applied Physics Laboratory: *The origin of chemical elements.*—It is generally accepted that the present relative abundance of elements was established in a prestellar stage of the universe. The direct correlation of relative abundance with nuclear binding energies has suggested to several investigators that the elements were formed in thermodynamic equilibrium at some high temperature and density in this prestellar stage. However, without assumptions difficult to justify physically, it is not possible to explain the abundance of both light and heavy elements as corresponding to equilibrium at a given temperature and density.

Because of the rapid change in physical conditions due to the universal expansion, Gamow suggested several years ago that some nonequilibrium process must have been responsible for the formation of elements. A process of successive neutron captures, with intervening beta-decay to correct the neutron-proton ratio, is indicated by the correlation of nuclei of large abundance with small neutron capture cross sections for these nuclei, and vice versa. Preliminary calculations indicate that a neutron-capture theory leads to the correct relative abundances.

The neutron-capture theory suggests that the cosmological model for the early stages of the universe is one of black body radiation, with a trace of matter present in the form of neutrons, protons, and electrons. Some 300 seconds after expansion began, the temperature had dropped to 10^{9}°K., below which temperature building up of nuclei by successive neutron captures could go on. At this time the density of matter was of the order 10^{-8} gm/cm^3. The process was terminated in a time of the order of a neutron decay lifetime by neutron decay and by the expansion. (*Author's abstract.*)

WALTER L. CHENEY, *Recording Secretary.*

Officers of the Washington Academy of Sciences

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JOURNAL
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GEOLOGY.—*Some aspects of the geology, petrology, and mineralogy of Switzerland.*[1]
PAUL NIGGLI, Mineralogisches-Petrographisches Institut der Eidgenossischen Technische Hochschule und Universität Zürich. (Communicated by GEORGE T. FAUST.)

The Alps are the youngest mountain range of Europe. Deep valleys, due to river erosion, allow the study of sequences of rocks, their metamorphism and folding within a thickness of some 2,000 to 4,000 meters. In many places a sparse covering of forest, scree, or snow is present; bare rocks can be found everywhere. So by climbing up the cliffs and gullies, by following the contacts of the rocks, and by collecting samples of rocks, fossils, and minerals, Swiss geologists and mineralogists have been able to build up a geological and petrographical synthesis of their country, based on evidence that can be directly investigated in the field.

Taken from north to south, the main zones found in Switzerland are as follows:

(1) The southern part of the *Schwarzwald* (Black Forest), a massif of Hercynian age, not folded in Tertiary times, upon which lies the Jura tableland.

(2) The folded Jura or Jura Mountains proper, resembling a virgation of the Alps and composed of rocks varying from Triassic to Tertiary age.

(3) The Swiss Plateau or Plain consisting of a huge thickness of relatively undisturbed marine and fresh water deposits dating from the Middle Tertiary. This rock assemblage is called "Molasse," a word originally meaning soft sandstone in the local Swiss dialect. Most of this material is derived from the Alps, in which erosion was setting in as folding and uplifting gradually began. Here also we find the more recent glacial deposits. fluvioglacial gravels, and sands of Quaternary age, filling out the deeper part of the broad valleys which traverse the Swiss Plateau.

The southern part of the Molasse region has been affected by the northward push of the Alps. The layers are no longer horizontal but steeply tilted and sometimes folded. The Alpine mountain chain had started to override its own debris.

(4) The fourth important zone in Switzerland is that of the High Calcareous Alps, which include rocks from the Perm or Trias to the Tertiary. These mountains belong to the main chain of the Alps. They show folds, nappes, and clean-cut thrusts of the sedimentary cover. The latter originates from the central massifs and is more or less autochthonous or may derive from the southern parts of these massifs. These sediments are said to be of Helvetic origin. From a general petrographic standpoint we can unite with the Helvetic High Calcareous Alps the so-called Prealps. These constitute an overlying mass of Mesozoic and Tertiary rocks, which in some cases are reduced to isolated outliers (Klippen), remaining in certain synclines of the Helvetic Alps. In other cases they form mountain areas built of material entirely foreign to the district in which they stand. The Prealps are composed of nappes piled up on one another, and there seems to be no doubt that they must be considered as frontal parts of Pennine or east-Alpine nappes that have traveled far to the north in Oligocene and Miocene times.

(5) In the western part of Switzerland, south of the Calcareous Alps, lies a broad

[1] Presented before the Geological Society of Washington, January 14, 1948.

zone of little-altered old igneous rocks, gneisses, and schists of pre-Triassic age. These are interrupted by zones of metamorphosed post-Triassic sediments. Conspicuous in this zone are the so-called *central massifs*, which bear the names Aarmassif, Gotthardmassif, Mont Blancmassif, and Massif of the Aiguilles Rouges. These massifs are composed of crystalline rocks of Hercynian age and were originally covered by others of post-Hercynian age, ranging from Permian to Tertiary. The Alpine folding pushed up, often as a series of slices, the rigid part of the massifs with the granite nuclei and old schists, while the softer and more pliable sedimentary cover was thrown into the succession of folds and nappes just referred to in connection with the Helvetic High Calcareous Alps. Between the crystalline wedges some of the roots of the Helvetic nappes are still to be found as more or less highly metamorphosed sedimentary synclinal zones.

(6) On the whole, the central massifs with their original sedimentary cover of epicontinental post-Carbonic rocks belong to the foreland of the great alpine geosyncline. To the south of the central massifs, however, we find the so-called Pennine Nappes, formed in the geosyncline itself. The rocks called "schistes lustrées" or "Bündnerschiefer" represent the metamorphosed sediments deposited in this geosyncline. But the older rocks now also form a series of nappes of which the Simplon-Ticino nappes are the lower elements. The Casanna schists of the higher nappes do not belong to the schistes lustrées of Triassic to Tertiary age, but are Paleozoic. Since they originate from similar sedimentary rocks, they often bear a strong resemblance in their metamorphic state to these schistes lustrées.

(7) In the eastern Alps the Pennine Nappes are overridden by the thrusts and nappes of the Austrides or eastern Alps. The lower part of this great overlap is very well developed in the Canton of Grisons, whence the name Grisonides that has been given to these units. The main part of the Austride nappes belongs generally to the southern coast or Hinterland of the main Pennine Syncline. And elements of this tectonic zone are also to be found in the western Alps in the zone of the nappe-roots and in the higher nappes. The Alpine geosyncline had, perhaps, a highly complicated structure and was divided into two main parts. It seems likely that the Austro-Alpine nappes belong to the so-called "Betwixt-mountains" and not to the hinterland of only one syncline. In any case the sediments of the Austrides are different in facies from the Pennine sediments, and there is no question of the foreward drive of these rocks over those of the northern main syncline and the northern foreland.

(8) In the Canton of Ticino and to the south of the steeply tilted zone of nappe roots lies a complex of old and younger rocks in fairly undisturbed position. They are regarded as belonging to the Dinarides and are called in Switzerland the rocks of the "lake district" (lakes of Lugano, Locarno, and Como).

From the standpoint of sedimentary petrography five examples are to be found in Switzerland of sedimentary provinces of the following types:

(1) *The Alpine diluvial-alluvial type of continental sediments.*—This is found in the topographically young region of high mountains and in the elevated features surrounding the Swiss Plateau. It is an association of residual and talus breccia, cave deposits, landslide deposits, cobble and boulder beds deriving from mountain rivers, pebble beds of fluviatile or fluvioglacial character, glacial boulder layers of various types, glacial drifts, grits, sands and silts of fluviatile, lacustrine, glacial, and aeolian derivation, loam of the slopes, muds, marls and clays, and freshwater or lake marls called "Seekreide" (that is, "lake chalk") with layers of peat and schistose lignites. These sediments are more or less unconsolidated and lend themselves readily to the study of mechanical and statistical analysis. Thus the shapes and mineralogical composition can be analyzed and determinations made of the origin and behavior of the material during the different kinds of transport.

(2) The *molassic* or *paralic* type of sedimentation in a continental trough, the last marginal deep of the alpine belt. The matter brought down by rivers and streams from

the alpine ranges which had been folded and uplifted during and after the Oligocene epoch, provides the constituents of the Molasse. The coarser conglomeratic deposits (Nagelfluh) are of the nature of shore or delta sediments, deposited under fresh-water or marine conditions. They play an important role in the topography, forming great cliffs as on the Righi. Sandstones, marls, and clays, sometimes with lignites and fresh-water limestones, are the other important rocks. Two continental periods are separated by a marine transgression and can be correlated with contemporaneous movements of the Alps. Interior compression persisted in the Alps during the Pliocene and led to the overthrust of the Helvetic Nappes over the Molasse. It can be seen from the nature of the pebbles and detritic minerals that the uplift and folding of the Alps began in the south. The first layers of the Molasse contain material from the higher tectonic elements only and were formed before the central massifs were pushed up and denuded of their sediments. At the close of the Pliocene the Alps finally rose up as a huge and lofty mountain range subjected to erosion by glaciers and rivers. Much work has been done on the characterization of the pebbles and heavy minerals, the processes of diagenesis, lithification, etc.

(3) *The true geosyncline* (*engeosyncline*) *type of sedimentation*, represented by a comprehensive series of sediments of great thickness and persistent facies, called schistes lustrées, Bündnerschiefer, and the younger Flysch. Interbedded in these sedi-

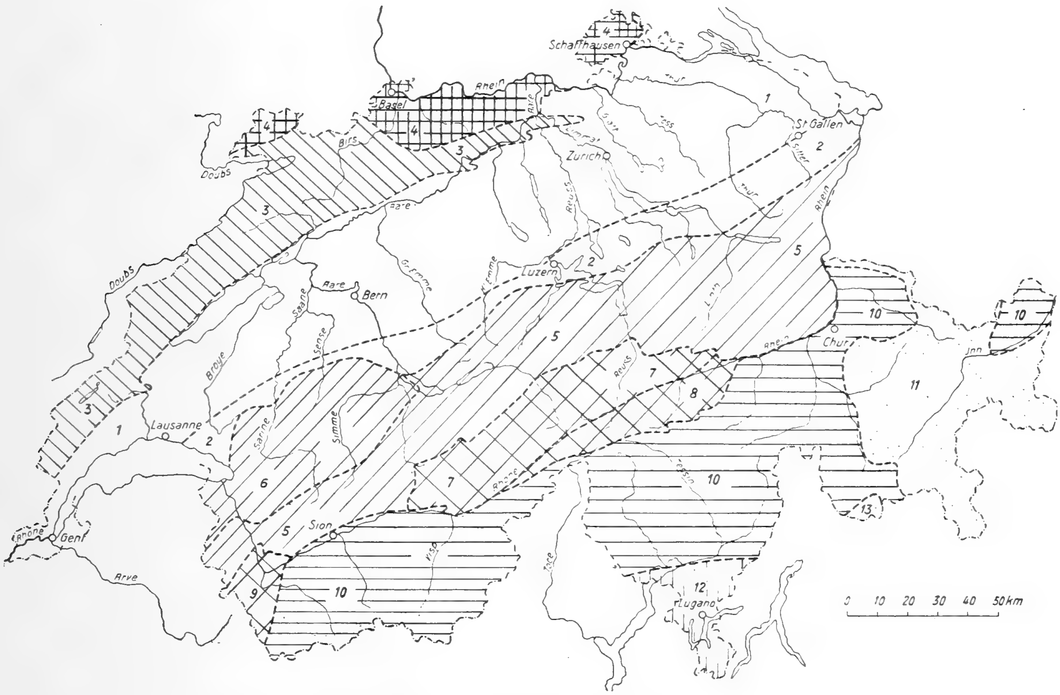


Fig. 1.—Sketch map showing the tectonic zones of Switzerland:
Zone 1: Swiss Plateau (Molasse Region)
Zone 2: Zone of folded Molasse
Zone 3: Jura Mountains
Zone 4: Black Forest-Massif (Hercynian)
Zone 5: High Calcareous Alps
Zone 6: Zone of the Prealps:
Zones 7, 8, 9: Central Massifs (7, Aarmassif; 8, Gotthardmassif; 9, Aiguilles-Rouges Massif)
Zone 10: Zone of the Pennine Nappes
Zone 11: Zone of the East Alpine Nappes
Zone 12: Lake District Mountains (Dinarides)
Zone 13: Tertiary Granite of Val Bregaglia

ments are layers of basic igneous rocks. The whole mass was afterward folded and transformed into calcareous phyllites, and greenstones or ophiolites. The series includes representatives of Triassic, Jurassic, Cretaceous, and in some regions also of Tertiary formations. Radiolarites with manganese ores and greenstones are found in some places, but a typical abyssal or bathyal facies is lacking. During the sedimentation the basin was steadily sinking, but in some zones the folding began to form islands, arches, and geanticlines. The Flysch furnishes ample proof that in the Eocene some folded chains were raised up and subjected to denudation.

(4) The *epicontinental type of sedimentation* is especially to be found in the Calcareous Alps and the Jura Mountains. It is characterized by regressions and transgressions and cyclical changes of facies. The sediments were laid down on continental shelfs and are of more or less neritic facies with frequent reef limestones, greensands, and oolithic rocks.

The Perm and Trias of northern Switzerland include continental and desert sandstones, dolomites, beds of gypsum and salt. They make it probable that evaporations occurred in lagoons and basins shut off from the sea.

This great variety of sedimentary provinces, the remarkable changes of facies, and the stratigraphical sequences have been an invaluable aid for the geological synthesis of the country. But for the petrologist the metamorphism of rocks during the Alpine orogenic cycle and the formation of mineral parageneses of a peculiar type have provided the more fascinating subjects to study.

As the Swiss part of the Alps is, from a tectonic point of view, one of the best-known young mountain ranges, it seemed a promising undertaking to study the relations between the tectonic events and what is called alpine dynamic and dynamic-regional metamorphism (dislocation metamorphism of the Swiss petrologists). It is to be remembered that we find in the Alps rocks of pre- and postcarbonic age and that many of the older rocks were folded in Hercynian time. This period of the Upper Carboniferous was also a time of great magmatic intrusions. All rocks older than Permian have for this reason undergone not only the Mesozoic-Tertiary dislocation, but at least one older dislocation metamorphism as well. In addition to these, an old contact metamorphism has left its traces at many places.

The rocks are, therefore, typically polymetamorphic, and at first sight it seems difficult to establish which of their present features are due to the influence of the young Alpine tectonic movements.

Three groups of observations have in the course of time helped in unraveling of the phenomena:

(1) In the *Schwarzwald* are to be found old rocks quite similar to those occurring in the central massifs and in the cores of many nappes. As the *Schwarzwald* region lay outside the Alpine orogenic area, such rocks have there been practically undisturbed since Carboniferous times. A comparison of the two regions gives clear indication of any changes the rocks have undergone since that time.

(2) Many of the great magmatic intrusions in the central massifs and in the nappes are in respect to the Hercynian folding of postorogenic character. The magma intruded at the end of the Hercynian folding and remained more or less unaffected by the latter. Analogous rocks in the *Schwarzwald* are true, unmetamorphosed igneous rocks. All changes suffered by their alpine counterparts must be ascribed to the alpine orogenic cycle.

(3) There can be no doubt that in many parts of the Alps the great masses of solid rock piled up to form the various nappes prevented magmatic solutions from ascending during the main period of mountain building and tectonic activity. Triassic and Mesozoic rocks are wedged between or folded as a whole into the older rocks and their metamorphism can only be of the pure Alpine dislocation type without any influencing by truly magmatic solutions.

In other parts, especially in the zone of nappe roots, magmatic migration was contemporaneous with some phases of the tectonic movements. There we find Triassic and Mesozoic rocks bearing the signs of

magmatic contact metamorphism combined with dislocation-metamorphism.

These indications will suffice to show that Swiss petrologists have a splendid working field in which to study the metamorphism of rock masses, subjected to external stress forces and when brought under new conditions of load and temperature.

You know that the results arrived at during the petrological exploration of the Alps have brought with them great advances in the science of metamorphism. I need only mention the names of Heim, Duparc, Grubenmann, and Koenigsberger in this connection.

The post-Permian rocks of the superficial nappes of the High Calcareous Alps, the Prealps, and the Eastern Alpine thrusts include dolomites, limestones, marls, clays, sandstones, and siliceous limestones. They have generally not suffered much alteration and resemble normal consolidated sediments. They do, however, show greater lithification and hardening than the rocks of the same age in the Jura Mountains and are often superior as building stones. But at the same time they have suffered an apparently plastic deformation and often exhibit very fine folding and overfolding. Such folding is often unharmonious, hard limestones or sandstones being frequently thrown into few large folds while marls and clays are puckered into numerous smaller ones. Harder strata also show the tendency to glide over the marls and clays and to fold separately or to break into pieces. But even in the folded rocks with flowage textures, joints, and fissures are everywhere to be found. When the latter occur in limestone, they are filled with calcite, while those in siliceous limestones, cherts, and sandstones predominantly contain quartz. Taken as a whole the rocks were during the period of folding a solid aggregate of crystals with increasing diagenesis. To a large extent the plastic behavior of the rocks was not due to the plasticity of the individual crystals. Different parts of each crystal and different crystals suffered different stresses. There was not only a differential movement of the grains, but also a recrystallization promoted by an interstitial liquid solvent, present in all these rocks. The solubility of a crystal is very sensibly increased under the influencing of shearing stress. Material can thus be dissolved where minerals or parts of minerals are under high stress and added to others or other parts, which at a given moment are not subjected to the same shearing stress. That solutions are effective even under these epithermal and not hypabyssal conditions is proved by new crystallizations out of solutions along cracks and fissures and in the pressure shadow of larger crystals or pebbles. Quite commonly open cavities or crevices were formed by tensional stresses in the anticlines and synclines of small folds and were then suddenly filled with crystallizing solutions. This seems to be analogous to the well-known quartz-filled saddle reefs, but the crystallizing material is always of the same nature as the rock minerals. There is no essential transport of material from depth, no material foreign to the rock to be found in such formations. This is the first what we may call embryonic stage in the formation of the so-called Alpine mineral fissures, taking place in this case under strongly epithermal conditions. Indeed at many places in the zone of the Calcareous Alps larger fissures are met with containing great crystals of calcite and sometimes of fluorite or quartz. Even in the Jura Mountains fissures occur with fine specimens of calcite, quartz, fluorite, pyrite, marcasite, celestite, and strontianite. There can be no doubt that they are the product of lateral secretion. In normal sedimentary rocks and in the small fissures only the minerals typical of diagenetically altered sediments are found. The temperature was too low to give more varied reaction products. But in some intercalations of peculiar composition, the same filled fissures, originally produced by stress, now contain a paragenesis of special minerals which can only derive from the surrounding medium. Thus at the Gonzen for example a bedded layer of iron manganese minerals, including hematite, magnetite, ferroan-calcite, hausmannite, rhodochrosite, calcite, and quartz, is intercalated between limestones belonging to the Malm. The Alpine dislocation metamorphism produced folding and fracture with a system of fine joints, cracks, and fissures in the ore

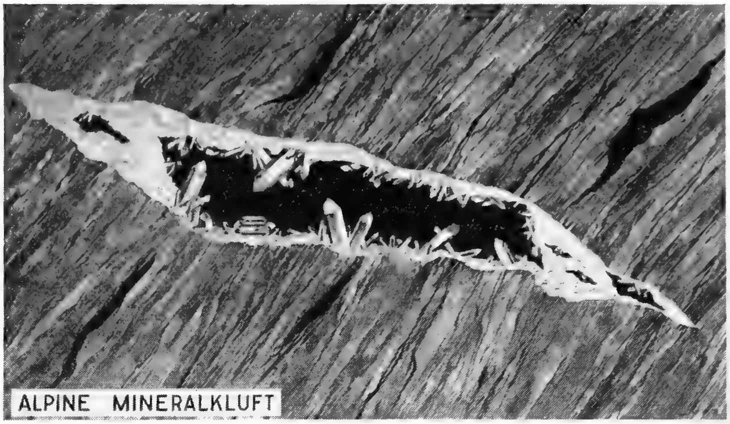


FIG. 2.—Typical alpine mineral fissure. Note the quartzband and the more or less vertical position in respect to the schistosity of the country rock.

deposit and adjoining rocks. In the iron ore the small veins and joints contain:

(1) Quartz, siderite, calcite, sometimes pyrite, or

(2) Stilpnomelane or ripidolite with calcite ± quartz.

In fissures within the manganese-rich part, the minerals are rhodochrosite and calcite, while in the limestone itself the filling of the fissures is restricted to calcite and sometimes a little quartz. Stilpnomelane, ripidolite, siderite and rhodochrosite are in this case the new epithermal vein minerals and correspond in composition to that of the mother rock.

A slightly higher degree of deformation is met with in an east Alpine complex of radiolarites, red shales, and aptychus-limestones with a concordant intercalation of manganese minerals, chiefly braunite. The ferruginous shales and the radiolarite (containing some amounts of sodium) are the rocks directly adjoining the manganese deposit. Within the radiolarites many of the very small fissures are filled with milky quartz; but in the manganese-ore, quartz is accompanied by new and peculiar hydrothermal minerals such as piedmontite, sursassite (a peculiar Mn-zoisite), parsettensite, manganiferous stilpnomelane, tinzenite, a Ca-Mn-silicate with water, sometimes rhodochrosite, magnanocalcite and rhodonite, also occasionally albite. Some of these minerals were first found in the fissures of this locality. As the dislocation and deformation of the rocks took place in several phases, veins of slightly different age can be observed with a normal succession of the minerals quoted. This is due to the fact that the temperature also was changing during the period of deformation.

Some illustrations will give you a good insight into the fissure system and its content of crystals. It must be added that the manganese minerals are only found in the fractured massive ore rock.

Thus we see that the content of the solutions had its origin in the rock itself and that the local formation of such solutions proceeded side by side with the processes of deformation and metamorphism which in this particular case was slight (formation of braunite out of silica- and manganiferous gels and recrystallization of the radiolarian ooze with partial destruction of the organic structure). The filling of and crystallization within the fissures and openings along the lines of fracture took place as temperatures tended to fall as a result of the gradual cessation of the mechanical strains and of increasing denudation by erosion.

This is, as we can prove by many examples, also the history of the formation of the Alpine fissures in the crystalline rocks of the central massifs and the pennine nappes. And it is these which contain the beautifully developed crystals so characteristic of the Alpine region, which have found their way into mineral collections all over the world.

Before giving a short summary of the parageneses of these interesting fissure-deposits (clefts) or "Zerrklüfte," as they are called in Switzerland, we must deal with the alpine metamorphism as manifested by the rocks in the central massifs and pennine region. To what extent the metamorphism assumes different grades according to the position within the system of uplifts and foldings, is best seen by a study of the wedged in or folded in syncliness of younger sediments.

Between the Aar- and Gotthardmassifs occurs a steeply tilted syncline composed of Permian, Triassic, and Jurassic strata. A crystalline thrust-wedge, the Tavetschmassif, divides the eastern part of this syncline into two parts. The southern part is called the zone of Tavetsch or Urseren and can be followed over a distance of more than 90 km along the northern edge of the Gotthardmassif from the Alp Nadels in the Canton of Grisons to the valley of the Rhone. The passes of the Oberalp and Furka as well as the Urseren valley have been carved out of it or the schists of the Tavetschmassif. The sediments are those of the normal cover of the Gotthardmassif with a thick layer of Permain facies called Verrucano, made up of detritus deriving from the Hercynian folding. The Trias is represented by quartzites, dolomites and dolomitic marls, and to the Lias belong sandy, often ferruginous limestones, sandstones, shales, echinodermal breccia, or compact limestones. The same strata, but without the Permian, are present in a sedimentary zone called the Nufenen Piora zone on the south side of the Gotthardmassif. Especially at the east end of the Gotthard pass, in the neighborhood of Lake Piora and Mount Scopi, parts of this zone are intensively folded and squeezed between the rising Gotthardmassif and the partly inverted frontal units of the deepest Pennine nappes. The push exerted by these nappes was very intensive in this region, and the erosion enables us to gain an insight into regions which were originally covered by higher elements of the upper Pennine nappes. There can be no doubt that this southern zone and also the southern parts of the crystalline rocks of the Gotthardmassif were subjected to higher stress and temperatures than were the zone of Tavetsch, Urseren, and the Aarmassif.

FIG. 3.—Quartzband with mineral fissures which have been opened up and emptied.

The metamorphic derivatives of the Triassic and Liassic sediments with remnants of fossils are as follows:

Northern zone:

Dolomite: sometimes converted to marble, sometimes crushed.

Dolomite marls: metamorphosed to chloritoid schist with chloritoid porphyroblasts and a groundmass of quartz, sericite, chlorite, hematite.

Calcareous sandstones and argillaceous sandstones: metamorphosed to so-called cipolin, a sericite quartzite with or without carbonate.

Clays: converted to phyllite.

Limestones: slight formation of marble and some crushing.

Southern zone with higher grade of metamorphism:

Dolomites: mainly converted to marble, sometimes squeezed out into lenses. Newly formed minerals include grammatite, actinolite and in some places phlogopite.

Dolomite marls: metamorphosed to mica-schists with biotite, hornblende and often garnet as porphyroblasts with often a little sodic plagioclase. In some zones it can be observed that chlorite and biotite were formed together while in a transitional zone sericite-albite-chlorite schists occur.

Calcareous marls and limestones: newly formed minerals are zoisite, epidote, garnet.

Sandstones furnish mica quartzites.

Clays: are transformed into beautiful mica-schists with biotite or cyanite and staurolite or garnet as large porphyroblasts. Sometimes hematite is replaced by magnetite.

All these schists have a freely developed crystalloblastic, porphyroblastic, or poicilo-blastic structure with crystal growth under stress. As a result of differential movement the growing porphyroblasts often show a marked rotation with S-shaped inclusions. The same is true of the chloritoid porphyroblasts in the chloritoid schists of the northern zone. Indeed, the movement of the chloritoid porphyroblasts in respect to the fine-grained ground mass may be so pronounced as to lead to the formation of crevices on both sides of the porphyroblast crystals. Such spaces became filled with solutions out of which crystallized unstrained individuals of quartz, chlorite, or sericite. This is another proof that already in the stage of metamorphism solvents were active and that solution followed by renewed crystallization was proceeding on a considerable scale.

In the southern zone the metamorphosed sediments are often of a coarse-grained nature and show no relicts of the original textures. Typical isometric porphyroblasts such as garnet may have diameters of 1 to 3 cm, whereas the length of cyanite, staurolite, or hornblende crystals may attain several centimeters in length. But in some of the folded and twisted rocks irregular open spaces are frequently found. They were filled with solutions from which quartz, idiomorphic cyanite, staurolite, and garnet free from inclusions have crystallized. So here again there can be no doubt that solvents were active during the period of metamorphism. Nevertheless, the succession of different metamorphic rocks, even when extreme folding has occurred, accurately reflects the original sedimentary sequence with very sharp boundaries between the original layers. No signs of long distance diffusions or metasomatism with solutions coming from below are to be found, and all observations point to recrystallizations from locally formed solutions during a long period of deformation.

Swiss petrologists call metamorphism of the type found in the northern zone of the Gotthardmassif *epimetamorphis.* The rocks there constitute an epithermal metamorphic facies. The metamorphism found on the southern border of the Massif and especially in the Lukamnier-Piora region, is termed *mesometamorphism,* and produces a mesothermal metamorphic facies. A study of the pre-Permain rocks in the Massif itself and of the rocks of the deepest Pennine nappes shows that the tectonic events there are correspondingly more intense. Judged from the same point of view it is to be expected that the metamorphism of the higher and more superficial Austride nappes will be of epizonal character, while in the Pennine roots katametamorphism is likely to prevail. For here intrusions of magma (basic at first, acidic later on) took place during the folding and invaded areas in which a slackening of pressure made itself felt. The reason for the latter was the squeezing out by the compressing forces of material, which making its way northward went to build the nappes.

It is not possible in this paper to discuss

in detail the correctness of these deductions. We must limit ourselves to an examination of the metamorphism exhibited by the old crystalline units of the central massifs, these being important as containing the chief localities at which fissure-minerals are found.

The older rocks of these massifs are as follows:

(1) Great complexes of diorites, granodiorites, granites and quartz-porphyries of the post-Hercynian epoch were found in upper carboniferous times. In the Aarmassif they are accompanied by syenites and monzonites with an intrusion of related magmas of rather greater age. Pegmatites, aplites and lamprophyres as well as porphyritic rocks are plentiful.

(2) The Hercynian magma was intruded into old paragneisses and mica schists with basic intrusions of amphibolitic or peridotitic character.

(3) A series of old orthogneisses with local occurrences of old hornfelses, conglomeratic gneisses, eclogites, and rarely of Paleozoic limestones.

Apophyses of the old orthogneisses and of the younger intrusive rocks have penetrated, digested and metamorphosed the schists. At some places fine examples of an old magmatization are visible and old injection gneisses are frequent.

(4) The permocarboniferous is often concordantly enwrapped and consists of sericite and muscovite gneisses and schists, conglomeratic gneisses, psammitic to pelitic gneisses with intercalations of permocarboniferous quartz porphyries, spilites and diabases.

The rigid masses of the Hercynian intrusive rocks and a great part of the old gneisses were not folded by the Alpine tectonic movements, which merely compressed these old Hercynian massifs.

The push of the Pennine nappes from the Alpine geosyncline was naturally stronger in the more southern massifs of the Mont Blanc and Gotthard than in those of the Aiguilles Rouges and Aar farther to the north.

The old massifs were uplifted and developed a more or less vertical schistosity. However as the push made itself most felt at the base, a fan-shaped structure has been produced at many places.

Phenomena of destructive metamorphism in the epizone are very widespread and include the formation slices, zones of mylonitic or crushed rocks, etc., features which are very conspicuous in the present morphology.

Every massif has one or two transversal anticlines, that is, culminations in the uplift, whose axes sink down on each side, producing a domelike shape. The greatest culminations are situated on a line running from north to south, from the valley of the Reuss to the valley of the Ticino and the Simplon-Ticino culmination. To the south of these massif culminations the deepest nappes outcrop in the depressions, while on each side the highest nappes are exposed at the surface and the deeper ones remain invisible in depth.

But the schists of the massifs have, as a result of the compression, everywhere been brought into a more or less vertical position. Only at the east end of the Gotthardmassif could the Pennine and Austrian nappes in the course of their northward movement thrust the sinking massif over the rocks of the Aarmassif.

In the main part of the Gotthardmassif the metamorphism of the old rocks often exhibits the following typical features: In rocks of massive texture quartz has suffered internal fracturing and possesses a cataclastic structure with some signs of recrystallization. Along the planes of strong differential movements the relicts of larger quartz crystals have assumed a lenticular or eye shape (augen) with mortar-structure in a finely crushed and sometimes recrystallized ground mass. In the mylonites the intensive crushing is combined with a schistose texture. But everywhere the destructive processes are followed by constructive ones, comprising not only recrystallization of the original constituents such as quartz, but also chemical reactions giving rise to new minerals. Sericite or muscovite is formed from alkali-rich feldspar, zoisite, and epidote from plagioclase, the mixture of these minerals with newly formed albite constituting what is called saussurite. Chlorite develops at the expense of biotite,

serpentine and talc from olivine and orthopyroxene, actinolite from augites and the more complex hornblendes etc. Many minerals of complex composition suffer unmixing accompanied by the formulation of iron-ore minerals, rutile, etc. Analogous mineral changes accompany the metamorphism of already metamorphic rocks and, as we have seen, the newly formed minerals in the younger sediments exhibit the same epimetamorphic character.

In the southern part of the Gotthard-massif in the so-called "Tremola-schists" and also in the deepest Pennine nappes a complete recrystallization of old and young rocks has taken place under mesozonal conditions. Granites have been transformed into two-mica gneisses. And in the zone of the nappe-roots where pegmatites strike across the schists, contact metamorphism of katazonal character is combined with the dislocation metamorphism.

One effect of the strain of the great tectonic movements, especially in the regions of the greatest uplifts, was the formation of torsion cracks and fissures. These developed in directions more or less perpendicular to the foliation or schistosity of the rocks and consequently lie horizontally in the central massifs and nearly vertically in the nappe-regions. Larger fissures resulted in massive rocks under relatively small loads than in finely foliated paragneisses or paraschists or in the region of the deepest nappes. Relatively large dimensions were attained by the fissures especially in the slightly epimetamorphic granites of the central massifs. Here open cavities of the size of caves were sometimes formed. The solutions circulating in the pores of the metamorphosed rocks filled the crevices and effected a very marked decomposition of the surrounding rocks. It thus often happens that the crevices are surrounded by narrow zones of altered or leached rocks. As the tectonic stresses gradually diminished and increasing erosion resulted in a reduction both in load and temperature, conditions were attained under which crystallization could take place out of these solutions or from others of low temperature which had joined them. The resulting crystals were able freely to develop into the spaces occupied by the solutions and thus to attain the size and perfection often characteristic of the alpine specimens. In many cases the leached zone became impregnated with newly formed crystals. This had the effect of sealing off the cavities and the contained solutions from their surroundings. Koenigsberger was the first to prove that the newly formed minerals found in the fissures are derived chiefly from the surrounding rocks. Lateral secretion during the period of tectonic deformations followed by crystallization from the cooling solutions are the factors leading to their formation. According to his estimates crystallization may have started at temperatures of about 350° and proceeded at intervals down to temperatures of 100° or lower. Many investigations (some not yet published) by students of the Federal School of Technology at Zürich have confirmed his results and furnished many additional details about the processes involved.

The best description and systematic arrangement of the various mineral parageneses found in the alpine fissures were given in the book published in 1940, *Die Mineralien der Schweizeralpen*, by my friend and collaborator Prof. R. L. Parker, who is also keeper of the well-known collection of Swiss minerals at the Swiss Federal Institute of Technology in Zürich. He divides the Swiss section of the Alps into twelve characteristic areas as follows:

1. Maderanertal
2. Guttannen-Goppenstein
3. Fellital-Giuf
4. Göscheneralp and Grimsel
5. Oberwallis and Urserental
6. Tavetsch and Vorderrheintal
7. Gotthardpass and Greina
8. Adula
9. Southern and easterly Grisons
10. Ticino
11. Binnental-Simplon
12. Zermatt

In each region he distinguishes a number of groups of localities comprising occurrences belonging to the same mother rock and of similar paragenesis. The connection that is thus brought out between mother-rock and mineral assemblages, is a typical feature of the Alpine-type localities and one that is only to be expected if Koenigsberger's

theory of lateral secretion is correct. Of the 58 groups described in the book only a few can be selected for mention here as illustrating the occurrence of typical Alpine minerals.

In the Maderanertal area, which is situated in the northern zone of schists in the Aarmassif, fissures in the paraschists show the following paragenesis of minerals: Quartz, adularia, albite, calcite, brookite, anatase, rutile, apatite, ilmenite, pyrite, sphene, and monazite. Of the TiO_2 minerals brookite is certainly the most conspicuous and these localities, which include the famous Grieserntal, furnish the best Swiss specimens today. Anatase is also frequent and the two minerals frequently show the phenomenon known as differentiation in the fissures. That is to say they either occur on different walls of the same fissure, or else appear separately in adjoining fissures. Cases are, however, frequent in which both minerals occur in close association, and are even joined by the third TiO_2 mineral, rutile. This is a quite anomalous state of affairs as according to physical chemical theory only one of these phases can be stable. Investigations in the laboratory has proved rutile to be the actually stable phase, and this is borne out by the observation that both brookite and anatase may be wholly or partially changed into aggregates of fine acicular crystals of rutile. Of the other minerals quartz may be mentioned as very frequently showing ghosts or phantoms as many as seven or eight being sometimes visible within a single crystal.

The importance of the TiO_2 minerals in the fissures of para-rocks is confirmed by the reappearance of similar parageneses in other areas. Thus in the now largely exhausted fissures of the Adula (area of Vals Platz) magnificent brookites 3 to 4 cm in length were found. Here also anatase occurred, and rutile often contained as needles in the quartz crystals has been found in superb specimens of rutilated quartz. In the Tavetsch valley, again, a similar paragenesis is found in para schists, though in this case anatase and rutile are generally far more important than brookite. The same is true of the fissures in the para-rocks of the famous Alpe Lercheltini near the village of Binn in the Valais. Here the conditions for the crystallization of anatase must have been ideal ones, for crystals of a size and richness in form development are found, which surpass anything found at other Swiss localities.

It is thus seen that while a given paragenesis may repeat itself at several or even many widely separated localities, each one of these exhibits its own local particularities as regards the mineral selection, form and habit development.

Returning to the Maderanertal, we find intercalated between the schists amphibolites deriving from basic igneous rocks. The assemblage carried by the fissures in these rocks is totally different from that just mentioned and can be given as follows: Calcite, adularia, quartz, albite, chlorite, amiant,[2] sphene, epidote, apatite, prehnite, pyrite. Especially the appearance of amiant, sphene, and epidote accurately reflects the change in chemical composition of the mother rock and gives rise to crystallizations as interesting in their way as the ones just described. In many of the valleys and ravines at the west end of the Maderanertal quite unusually rich crystallizations of amiant occur. The mineral is often of almost hairlike habit and may occur in loose heaps or in a more or less fluffy or felted state of aggregation, often resembling animal fur. On the other hand, it may also assume a more leathery consistence. At some localities in the west, but especially to the east of the Maderanertal at the Alp Cavrein, epidote is found in large crystals rich in faces and the same is true for crystal lizations found in the frame work of this paragenesis in other areas, for instance at the Kammegg near Guttannen. But quite the most famous instance of this type of epidote occurrence lies in the Tyrolese Alps in the eastern Alps. The Knappenwald locality in the Untersulzbachtal produced what were certainly Europes finest epidotes in exactly the association given above and formed under just the conditions and in a similar mother rock as at the Swiss localities.

[2] An exceedingly fine silky variety of asbestos.

Sphene is a very notable constituent of fissures of this type in some areas, three well-known examples being the Drun Tobel just north of Sedrun in the Tavetsch valley, the Motta Nera in the val Nalps and the Alpe della Sella. The first and last named of these places have been famous for large sphene crystals, in fine V-shaped twins, for many years. They are often of yellow color. passing abruptly to green at the ends where the binary axis passes through the crystal. The Motta Nera area is a comparatively recent discovery which has supplied not only excellent dark brown sphene but also prehnite in profusion and sometimes very large crusty specimens. An interesting feature of the calcite found in this paragenesis is the fact that the early crystallizations are tabular in habit, while at later stages the chief rhombohedron tends to develop strongly. Thus calcite plates are sometimes found covered by rhombohedral elevations.

Rather similar to the amphibolite paragenesis is that carried by the fissures in the so-called potash-syenite of the Piz Giuf area. The following list of minerals shows, however, that the zeolite minerals are often much more plentifully represented than in the last case where they are of more incidental occurrence. The mineral assemblage for syenite fissures is as follows: quartz, adularia, calcite, chlorite, desmine, scolecite, stilbite, apophyllite, laumontite, chabazite, amiant, apatite, sphene, epidote, milarite, etc.

Amiant is one of the first minerals to crystallize and in these fissures is often shorter and stiffer in form that in the occurrences mentioned just now. A point of genetic interest is the very intimate relationship between this fissure mineral and the hornblende in the rock which sometimes shows signs of recrystallization on the fissure walls with transitions into amiant fibers. At the other end of the sequence of crystallization lie the zeolites which are among the last minerals to separate. In rich associations comprising all the species just mentioned, they form crusts covering the other minerals and especially the quartz crystals, following every detail of their contour. It is as though a semiplastic mass had been molded around the earlier formed minerals. An interesting specimen in the Zürich collection is a fairly large quartz crystal which, having attained a certain weight, broke off from the wall of the fissure at the bottom of which it was found. The fractured surface has become covered by aggregates of desmine which proves that the break occurred while crystallization was still in progress. It is in fissures of all types a common occurrence for quartz to break off and then regenerate the fractured surface, producing finally crystals without any apparent center of growth.

In the syenite fissures the quartz crystals are colorless to dark brown or even black, the latter being called *morion*. These varieties appear at quite different localities, the general rule being that the darkest colored crystals come from the highest points and usually from such at least 3,000 m above sea level. This peculiar fact is explained by Koenigsberger as follows: The dark coloration is produced by the radioactive influence of certain constituents in the mother rock. In order for these to be effective, low temperatures are required which is, of course, the case at the highest localities. Strict comparisons on these lines are only possible when, as in the Giuf area, higher and lower localities within the same mother rock are available. Many of the quartzes from here are beautifully developed with several broad trapezohedron forms beside the S-faces. They nearly always show signs of Dauphiné twinning, the combination of two right crystals being, as several statistical counts have shown, of the same frequency as the left+left combination. It must, however, be added that extensive research, carried out on quartzes from these and other Swiss localities, have shown the individuals to possess a very much more complicated system of twinning (including the brazil law) than can be inferred from the face development alone. The Giuf localities are one of the main sources of what Swiss collectors call "Gwindel," that is, twisted quartz crystals. These, as is well known, consist of a series of individuals each slightly rotated in position against their neighbors. The degree to which these various crystals are intergrown varies very much from specimen to specimen.

Some show very clearly where each individual ends and the next one begins and are called "open" specimens. "Closed" specimens are those in which the intergrowth is so complete that all individual points have disappeared and have been substituted by one long curved edge.

In some fissures from marginal areas of the syenite the quartz crystals often contain long hollow cavities of rectangular cross section. It has been shown that they originally contained anhydrite which has, however, been redissolved, leaving the hollow shape of its crystal form. This redissolution took place fairly early as zeolite minerals have often been deposited within these "air pipes" as we call them.

Let us finish this brief survey of the Val Giuf minerals with a mention of the interesting mineral milarite, so-named by one of my predecessors in Zürich after the Val Milar. Unfortunately the mineral does not occur at the locality after which it is named, Professor Kenngott having been the victim of a deception on the part of the original finder. The actual locality, as is now known, was the Giuf glacier, and a pupil of mine, Mr. Huber, has recently found new occurrences with some exceptionally large crystals. Milarite was originally considered to be a potassium-calcium-aluminium-silicate, but Prof. Charles Palache in 1931 showed that it contains beryllium in addition to these elements.

Of the greatest importance for their mineral fissures are the great granite areas of the Aar and Gotthard massifs. In the Aarmassif the granite forms one connected mass, stretching from the Grimsel area in the west to beyond the Reuss valley in the east. The fissures throughout this broad expanse of mountains all bear much the same paragenesis consisting of: Quartz, calcite, chlorite, fluorite, apatite, hematite, pyrite. Adularia and albite are not plentiful in these fissures, which in this respect form a contrast to most others. Accessory minerals are zeolites, epidote, sphene, TiO_2-minerals, and, rather strangely, galena, a clump or two of which is often found with the ordinary minerals.

The fissures in this area are often of quite exceptional size and have sometimes attained the dimensions of caves in the rock. This was the case at the famous locality found in 1866 at the Tiefenglacier and again at a spot quite recently discovered in the same neighborhood. It must not be thought however that on entering such a cavern the discoverers found the walls covered by beautiful crystals. Quite the reverse was the case. For in the available free space the quartzes had grown to a size and weight

FIG. 4.—Exploitation of the large mineral fissure on the Tiefenglacier in August 1866 (contemporary etching).

which caused them to break off from the walls and fall on to the floors of the cavities. However, as there had previously been copious crystallizations of sandy chlorite material, they feel on to a soft yielding mass and so remained imbedded in this material and quite undamaged. Crystals from the old Tiefenglacier locality attained a length of $2\frac{1}{2}$ to 3 feet and in some cases a weight of 250 to 260 pounds.

These very large fissures are remarkable also for their very broad quartzbands. These consist of granular or massive quartz which forms as an early crystallization at the tapering ends and around the fissure-

cavities proper. Most fissures possess more or less quartzband and are frequently discovered by the appearance of this massive quartz on the rock surface. But in these cases the bands attained unusual dimensions, sometimes as much as 7 feet. The exploitation of this fissure assumed the proportions of a small mining operation, regular adits being driven into the rock. That was late in the seventeenth century, a time when the collectors were only interested in the rock crystal. What is really the most beautiful mineral of this paragenesis, the fluorite, they threw aside and it has remained for collectors of later generations to appreciate and study this mineral. It possesses a very remarkable rose red or pink color quite unlike the fluorite found elsewhere. Many crystals are uniform in color, but in a beautiful lot of specimens in the Zürich collection the cores of the crystals are pink and the surrounding layers quite colorless. The commonest form is the octahedron, though the bicolored crystals just mentioned show the cube also, and others a trace of the rhombic dodecahedron. It was long believed that the Aarmassif alone possessed these pink fluorites, but material of similar color has been found in pennine series of the Adula, and in an occurrence in the Gotthardmassif (Nalps glacier) which aroused much interest in 1938.

The granite of the Gotthardmassif is (in contrast to the Aarmassif) not one connected mass, but divided into several separate units of rather different mineralogical and structural composition. To the mineralogist one of the most interesting varieties is the Fibbia granite, a rather porphyritic rock, building the mountains surrounding the Hostel on the Gotthard pass. It contains many fissures whose characteristic paragenesis is as follows:

Adularia, quartz, albite, muscovite, chlorite, hematite *or* apatite (these minerals very seldom occur together), and accessories such as zeolites, pyrite, some TiO_2-minerals, etc. The term adularia as we understand it generally applies to a colorless transparent potash feldspar with rather pronounced pearly luster and a typical crystal habit dominated by (110)($\bar{1}$01) and small to medium faces of the basal plane (001). The general aspect is sometimes rather pseudorhombohedral in character. But many occurrences of adularia show that these features do not always appear together. Thus many fissures contain milky white crystals of only translucent or even nontransparent character. On the other hand, the fissures of the Gotthard granites show that typically transparent adularia may assume the elongated prismatic habit of the Baveno type. The fine crystals found in this area are very often complex twins, consisting of four individuals of which adjacent ones are twinned on the Baveno law while opposite ones show twinning after Manebach. The appearance of muscovite in the paragenesis is a characteristic feature not found in the more northerly Aarmassif. But undoubtedly the main interest of these occurrences concentrates on the minerals hematite and apatite which are found in specimens of outstanding quality.

The hematite of the Gotthard pass is of pronouncedly tabular habit and on the whole not very rich in faces. It shows the tendency to form subparallel aggregates much resembling the arrangement of petals in a filled rose bloom, and this comparison has caught the imagination of the collectors, who have long since chosen the name of iron roses for these groupings.

Very notable specimens have come from these fissures, some of the finest being as big as a fist and showing brilliant metallic luster. Comparisons could be made between these hematite crystals and the crystallographically very much more complex specimens occurring at the Alp Cavradi south of Tschamutt in the Tavetsch valley, but this would take more time than we can spare now.

Turning to the apatite crystals, we can only suppose that the conditions for the formation of this mineral were quite ideal ones, for in some fissures it occurs in very numerous individuals, of sometimes large size and always very complex development. It is no rare thing to find 50 or 60 perfectly reflecting faces on one small crystal which may be tabular, short or long, prismatic or occasionally bipyramidal in habit. The crystals are colorless or sometimes of a pale violet color which, however, like the

violet of the rare Swiss amethyst, fades in sunlight. Some recently found large crystals are practically opaque and milky white.

In a granite area farther east called the Cristalina granite, a paragenesis of other character is found in rather plentiful occurrences. It contains the following minerals: Adularia, albite, quartz, chlorite, calcite, muscovite, axinite, apatite, epidote, sphene. It is the axinite which distinguishes these localities and often appears in excellent large-sized crystals. Many of them are chlorite covered and then gray green in color and without luster; but on specimens free of chlorite the crystals are of a brilliant purplish to reddish-violet color, and in every respect equal to the famous ones from Bourg d'Oisans in the French (Dauphiné) Alps. The appearance of this boron-silicate in some quantity is interesting and not easy to explain satisfactorily out of the mineral and chemical composition of the mother rock.

To the south of these granites follows the zone of the so-called Tremola schists, which have many fissures with the following mineral assemblage: Albite, quartz, calcite, siderite, ripidolite, rutile, tremolite or amiant, tourmaline, pyrite, etc. A remarkable feature of the specimens from these localities is the morphological development of the quartz crystals which contrast sharply with those found in all the more northerly occurrences. The faces of the prisms and of the unit rhombohedra are often reduced to fairly small dimensions, while those of numerous acute rhombohedra dominate the habit. This gives the crystals a peculiar tapering aspect, which is quite typical for the zone in question, but is also found in the Pennine areas of the Ticino. The habit has therefore been called the Ticino-habit and constitutes a classical example of how the development of a crystal habit depends upon the surroundings and circumstances under which it is formed. These quartzes are of quite unusual limpidity in spite of the fact that they are often full of inclusions, these latter consisting chiefly of chlorite, tremolite and tourmaline.

Passing to the fissures of the Pennine nappes, we can only briefly mention the famous locality of Campo Lungo, where the white saccharoid dolomite marble contains many fissures with grey grammatite, bright green tourmaline, reddish or bluish crystals of corundum, diaspore and beautifully developed and twinned crystals of dolomite. Near here a unique paragenesis was found in fissures of a calcareous phyllite. It contained scapolite crystals of gem quality which are quite unlike any other alpine occurrence of this mineral.

A few words must be devoted to the contents of the fissures found during the construction of the Simplon tunnel. The paragenesis included very rich crystallizations of calcite, dolomite, and siderite beside beautiful violet crystals of anhydrite. Quartz, adularia, albite, chlorite, rutile, muscovite, and the rare hamlinite (Al-Sr-phosphate) were other minerals. Both in composition and aspect these crystallizations are markedly different from the mineral assemblages found in more superficial fissures. It is worth remarking, however, that in other tunnels such as the Gotthard and also in some underground workings as for instance at Monte Piottino, rather similar formations have been met with. This raises the question whether with increasing depth the character of the fissure fillings undergoes a certain change and whether these "tunnel parageneses" as we sometimes call them, are indicative of the type of mineral formation prevalent in lower levels than those usually accessible.

Fig. 5.—Iron rose (Binnental area). Typical subparallel aggregate of tabular hematite crystals.

The most famous locality in the Pennine area west of the Ticino is, of course, the Binnental. Reference has already been made to the superb anatase crystals from here and I shall presently return to the unique mineral assemblage found in the white saccharoid dolomite rock at Lengenbach.

Let us now conclude this very rapid survey of the Alpine fissure deposits with a brief glance at the famous minerals from the Zermatt area. These are contained in fissures of basic rocks (metamorphosed gabbros, peridotites, etc.) and also in rocks produced by contact metamorphism of the basic igneous rocks on limestones. Garnets, both red and green, the latter sometimes in large nodular masses, idocrase in lustrous beautifully developed green or brown crystals, epidote and large well-developed pseudorhombohedral crystals of pennine are among the minerals more commonly met with. Perovskite is rarer but also of fairly frequent occurrence, sometimes in honey yellow or orange colored nodular masses, sometimes in well formed reddish brown cubes. Another mineral sometimes met with is lasulite in sky blue masses, which can be cut and polished to make attractive gem stones.

It is in general true to say that all the important chemical elements found in the rocks are also represented in the fissure minerals. In what particular mineral or minerals each element is contained, can best be seen from Table 1. Under epi to meso conditions the metamorphic processes run more or less concurrently with the formation of the crystals in the fissures.

The general succession of order of crystallization of the fissure minerals is given in Table 2.

The observed facts can be summarized as follows: The crystallizations often begin with the formation of alkali feldspar or epidote or amiant. In later stages water-rich minerals such as muscovite and the zeolites are formed beside oxides such as hematite, rutile, etc. From the residual solutions which have become poor in alkalis and rich in Mg and carbonate ions, chlorite and the carbonates are the chief minerals to crystallize. Quartz is in the fissures of silica-rich rocks, an "ubiquitous" mineral, that is to say one that can appear in practically all parageneses and at all periods of the crystallization. In especially quartz-rich rocks, quartz is without doubt the dominant fissure-mineral. Fluid and gaseous inclusions in which the bubbles disappear on heating, sometimes enable estimates to be made of the temperatures and pressures prevailing at the time of crystallization.

The fissure minerals of the Alpine type are scarcely found elsewhere in the same parageneses and development. Even in the

Table 1. Chief Processes Leading to the Formation of Fissure Minerals

Original minerals	Processes	Crystallization of:
Plagioclase	Decomposition of the calcian feldspar molecules; solution	Epidote, prehnite, calcian zeolites, albite, carbonates, quartz
Alkali-feldspars	Unmixing and partial solution	Potassian feldspar (adularia) and sodian feldspar (albite), rarely of alkali-zeolites
Biotite	Separation of TiO_2 and Fe-oxides; release of potash	Chlorite, hematite, limonite, Ti-oxides, beside adularia and quartz; sometimes formation of Fe- and Mg-carbonates
Augites and hornblendes	Loss of Al, Ti, Ca, often Fe-decomposition and solution	Epidote, hornblende asbestos, calcian zeolites, calcite, dolomite, Fe- and Ti-oxides, or titanite, quartz
Olivine	Hydrolysis, loss of Fe oxidation	Serpentine or talc and magnesite together with Fe-oxides
Quartz	Partial solution	Renewed crystallization of quartz
Carbonates	Partial solution	Renewed crystallization of carbonates

Table 2. Sequence of Crystallization of Minerals in Fissures of Gneisses and Mica-Schists

Water-free or water-poor silicates	*Early stages of crystallization:* Amphibole-asbestos, epidote, adularia, usually also quartz.		
	First succession: Albite, tourmaline, apatite, rutile, anatase, sometimes hematite, anhydrite.	Continued crystallization of adularia and epidote	Continued crystallization of quartz
Water-rich silicates, oxides, carbonates	*Second succession:* Muscovite, titanite, hematite, brookite, fluorite, chlorite, carbonates.	Continued crystallization of some minerals of the first succession	
	Final crystallization: Calcite, chlorite, prehnite, zeolites.		

Alps conditions favorable for their formations were not everywhere present. They are found especially in the following regions: The central massifs from Pelvoux, Grandes Rousses, Belledone in the Dauphiné to the Mont Blanc-, the Gotthard- and Aar-massifs, the Pennine nappes from the Simplon to the Adula and the great culminations of the Zillertal alps, Grossvenediger and Sonnblick-Hochalm in the eastern Alps. All these regions are transversal culminations or anticlines of the Alpine arc. In the neighborhood of these great anticlines (and not in the tectonic depressions) conditions were favorable for the formation of open fissures during the uplift. This in turn was a necessary condition for the circulation of the solutions which having gathered their material, were able to deposit it in the open spaces and give rise to the mineral specimens we now admire.

As the chief rocks of the Alps are of normal chemical composition, the common fissure minerals themselves are of quite usual composition also. But where rocks of special character and chemical composition were concerned, the peculiar genesis of the fissure minerals finds its expression in the appearance of rare mineral species.

This has already been pointed out in connection with the manganese ore deposits and further confirmation is furnished by the classic mineral locality of Binn in the Canton of Valais. With the Triassic dolomite rock, found there, is incorporated a sulphide layer containing as primary minerals pyrite, a little argentiferous galena and blende, chalcopyrite, and arsenopyrite. During the Alpine metamorphism the dolomite was converted into a saccharoidal marble while in small cavities new minerals of the sulpho-salt-type were formed which are for the most part exceedingly rare species. They include lengenbachite, rathite, hutchinsonite, seligmanite, baumhauerite, dufrenoysite, jordanite, and sartorite, most of which were first described from this locality and some of which have never been found elsewhere. Tennantite, realgar, orpiment, proustite, barite, hyalophane, and dolomite are other minerals occurring in these fissures.

Such special paragenes allow a comparison to be made with those of the ore deposits, as given for instance in Lindgren's classification. Judged by their mineral content and temperature of crystallization the alpine fissures may be called an autochthonous hydrothermal type of deposit of meso- to epithermal character. They are related to ore deposits formed near the surface and also to the deposits of native copper and zeolites in the Lake Superior region. What is essential is the recognition of the fact that the fissure minerals were formed in a more or less closed system during the dislocation and metamorphism of the rocks without the participation of substances contained in solution by ascending waters or liquors.

Let us recapitulate:

After the chief system of nappes had

already developed in the Alps, a very pronounced longitudinal corrugation came into being during the last phase of the compression of the Alpine chain. As a result of the obstruction offered by the crustal masses in the foreland great culminations and depressions gradually took shape while the flat mountain land was erected into a system of high mountains. Erosion set in and became increasingly active, though it could not keep pace with the uplift or carry away what the folding had built up. In the culmination zones and particularly on the flanks of the chief uplifts fissures were formed and quickly filled with aqueous solutions. These thermal waters had become charged with substances previously dissolved from the surrounding rocks. Crystallization from these solutions set in as the effects of gradually diminishing pressure and temperature made themselves felt. In the course of long crystallization processes crystals of unusual perfection were formed which today are the ornaments of the high Alps. The composition and associations of these minerals give indications as to the temperatures which must have prevailed in the mountain area at the time of their formation. Crystal species which at an earlier period had been formed in the rocks are found to have become unstable and to have undergone unmixing and decomposition, thus giving rise to other minerals. The search for and collection of these crystals not only provide aesthetic pleasure but also furnish much valuable information about the formation of the Alps themselves, of the mountain range, which is the backbone of Switzerland.

BIOLOGY.—*The principle of priority in biological nomenclature.*[1] RICHARD E. BLACKWELDER, U. S. National Museum.

An article under this title by Dr. A. C. Smith of the Arnold Arboretum appeared in Chronica Botanica **9**: 114–119. 1945. It consists largely of a critical review of a paper from the zoological viewpoint by Franz Heikertinger, published in 1942 in Germany[2] which is "an undisguised attack on the principle of priority"[3]

Both Dr. Heikertinger's proposal of a principle of continuity and Dr. Smith's critique are of interest to taxonomists in zoology as well as in botany. The present remarks are intended to expand Dr. Smith's review and to carry on the arguments against Heikertinger's proposal.

The goal which Dr. Heikertinger hopes to attain with his new proposal is very attractive. It is that *within 30 years every species of animal will have one single universal name in use.* This is the millennium in nomenclature, the goal of complete stability which has seemed so far away to most taxonomists. This goal is to be attained by discarding the principle of priority and substituting for it the so-called principle of continuity, that "the valid name of a genus or species is the one which the monographer finds in scientific usage, regardless of whether or not this is the earliest name."

This statement of principle immediately raises several questions which must be satisfactorily answered before the principle could be applied in actual practice. (1) Who is to be accorded the status of monographer with authority so much above the ordinary taxonomist? (2) If monographers disagree, which is to be accepted? (3) How can biological considerations be kept separate from nomenclatural ones, or, as Dr. Smith implies, are biological facts to fall at the monographer's whim along with the nomenclatural ones? (4) What will happen when the monographer bases his work on totally inadequate bibliographic or taxonomic research and makes an obvious and demonstrable error? (5) Would complete stability be reached even with the elimination of purely nomenclatural changes?

(1) Apparently the question of who is a monographer is not discussed by Heiker-

[1] Received May 14, 1948.

[2] HEIKERTINGER, FRANZ. *Das Nomenklaturproblem der Gegenwart. Zugleich ein Aufruf an alle Biologen.* Der Biologe, 1942: pp. 20–27.

[3] Direct quotations are from Dr. Smith's paper.

tinger. There is an implication that the monographer is someone special, readily distinguished from other workers. One group of "monographs" is mentioned that may give us a clue. Heikertinger states that zoological nomenclature was more or less established about 1850, because of the thorough monographs of that period. Since Heikertinger is an entomologist, these monographs were probably the large regional works such as the Naturgeschichte der Insecten Deutschlands, and the numerous large works of Erichson, Kraatz, Redtenbacher, Mulsant, and others.

These works were of restricted geographical scope, being in fact not true monographs at all but revisions of the species of one region. They doubtless helped to fix names in use locally for a few years, but their influence in the long run depended upon their accuracy in a broad sense. Stable nomenclature can not be based upon the names in use in one region, and it is to works of this sort, based on less than a world viewpoint, that we owe much of the confusion in names with which we now contend, because the names were thereby brought into common usage. A monograph of a genus or large group for the world will give the only sound results, both taxonomically and nomenclaturally. There have been works of this nature in many groups and at many times, but no decade produced enough to claim a stabilizing effect on all zoological nomenclature.

A publication that has the appearance of being a monographic study may fall far short of complete or adequate treatment. For example, a recent work on a world-wide genus of insects, purported to deal with all the known species. It gives keys and descriptions and distribution and was based on extensive material obtained from all over the world. The work thus purports to be a monograph of the genus. Yet on closer examination it appears that at least half of the specific names that had previously been used in the genus are not mentioned, and numerous cases of homonymy and objective synonymy are completely overlooked. Even if the zoological aspect of this study is thoroughly and competently treated, the nomenclatural treatment is so bad that the revision is nearly useless. It is even possible to find the genotype of one subgenus listed in a different subgenus! To accept this work as a monograph for the purpose of stabilizing names would mean throwing overboard not only the principle of priority but also the concept of genotypes as the anchor of generic names and the requirement of thoroughness and accuracy for general acceptance.

In short, the only way to define a monograph in the sense of Heikertinger would be to set up an authority to pass on each publication. Acceptance of any given work as a monograph on a certain group of animals would automatically set up a list of *nomina conservanda* for both genera and species in that group, except for changes required on taxonomic grounds, as will be discussed under question 5.

(2) Disagreement between monographers would be taken care of by the authority mentioned above. If the acceptance of one work as a "monograph" did not serve to discourage a later work on the same subject, the authority would have to pass on the later work when it appeared. Rejection of the later work would uphold the earlier one, but acceptance of the later one would perhaps reverse some nomenclatural as well as taxonomic decisions and cause name changes.

(3) Many apparently nomenclatural decisions are based at least in part on purely taxonomic considerations. Under the law of priority, the correct name for any species is the oldest nonpreoccupied name that has been applied to it, *assuming that unrecognized biological identity with another so-called species does not exist.* This assumption is seldom expressed but always exists. When it can be demonstrated that there *is* taxonomic identity, there is certain to be a change in the status of one of the names. This change is nomenclatural and is made because of the law of priority, and yet abolition of that law would not prevent the change because of the biological considerations.

Nomenclaturally we hold that each genus must have a type species. The actual identity of that species cannot be determined nomenclaturally, however, for it is

necessary to make at least a morphological study of the type specimens of that species to demonstrate its characteristics. Under a recent interpretation, apparently employed by the International Commission in Opinions 168, 169, 173, 175, 177, 179, and 181, it is even necessary to examine the specimens that were before the worker who subsequently selected the genotype. These are biological considerations, although the problem of genotype fixation is generally thought of as primarily nomenclatural.

It is simply impossible in many cases to separate taxonomic from nomenclatural considerations, and if nomenclatural problems are to be decided by the whim of a monographer, it is difficult to see how we can prevent confusion of the taxonomic facts. Dr. Smith interprets Heikertinger's position thus: "These zoological monographs, one is led to believe, should be preferred to the older often superficial works, even when the monographic concept of a species differs from the original concept, and even when this difference in concept is caused by the monographer's misinterpretation of an earlier writer's type specimen."

(4) Heikertinger appears to believe that a monographer will always be in a position to make a sound decision on which name is in current use. Yet very few studies take into account *all* the previous literature and *all* the previous specimens. In actuality our monographs vary from this down to mere compilations or condensations which critically evaluate none of the previous work.

Some decisions of some monographers would inevitably be demonstrated to be based on inadequate or erroneous data. To refuse to reverse such a decision would be ridiculous, yet the principle of continuity would require just that.

If writer Jones finds that *P. niger* is in use and is to be retained over the older *P. obscurus*, does this decision give permanence to *P. niger* even when it is pointed out that Jones failed to note that *niger* is a junior homonym? This is a strictly nomenclatural change, but if both *nigers* are in current use, continuity could save only one of them.

In view of the low quality of the bibliographic work of some monographers, it is likely that in some cases a later monographer would be able to prove that the first monographer failed to consider a large number of pertinent works which would tend to reverse his decision. One world authority on a family of insects is unable to keep track of even his own proposals. He has repeatedly used a name in one genus not twice but three times. In one case, discovering the homonymy of two of his names he renamed the younger. The new name was promptly recognized (by another worker) as a homonym of another of his and renamed. Several years later this writer *rediscovered* the original homonymy and again renamed it, using the same new name as before, now twice a homonym as well as a junior synonym. This same writer habitually pays no attention to genotypes. It is not difficult to believe that any nomenclatural decision he made in a monograph or elsewhere is at least likely to be seriously defective.

(5) It is a popular pastime among certain biologists to ridicule the taxonomists for the large number of name changes that are made, generally implying that it is because of religious fervor for certain Rules of Nomenclature that such changes are proposed. In this way nomenclature is often made to take the blame for all changes of name. There can be little doubt that this is a most misleading assumption. Many names are changed because of discovery of older synonyms or the recognition of forgotten homonyms of prior date. These are the only truly nomenclatural changes. But many more changes are made (at least in some groups of organisms) because of generic transfer, proposal of segregate genera, recognition of generic equivalence, and similar purely biological considerations. And many are made because of nomenclatural requirements growing out of zoological actions, such as renaming of concurrent homonyms produced by union of genera. In many groups it is not difficult to demonstrate that a substantial majority of changes of names over a period of years has been caused by the second and third means listed above, namely those involving zoo-

logical actions rather than exclusively nomenclatural ones. These changes can not be prevented at all by the "principle of continuity."

If Heikertinger's proposition were to be adopted and means provided to make it work, we would still have changes of names as long as students search out new facts of relationships of organisms. Some changes would be prevented, it is true, but these could probably be prevented more easily by other means.

The overemphasis on the need for complete stability of nomenclature is demonstrated by a quotation by Dr. Smith from a German botanist. This botanist contends that we fail in our responsibility to our studying youth by making them unlearn the names each semester to follow the latest changes. Dr. Smith replies that this exaggerated statement "scarcely causes us to shed a tear, since this same (student) is expected to discard preconceived notions of all other branches of biological science at the drop of a chromosome. Why is it that workers in other fields of biology expect absolute stability of systematics (that is, comparative morphology and its attendant nomenclatural expression), while they are willing to accept any degree of flux in the fields of genetics, physiology, cytology, and . . . sociology?"

The reason for this emphasis on stability is doubtless the desire of these scientists to have means of tying their experiments and theories definitely to specific kinds of organisms, in order to use them for synthesis and generalization. But this desire for fixed names is impossible of gratification under any system as yet dreamed of and should not be given consideration over the necessity of the science of taxonomy for growth and development itself. All means should be found to prevent unnecessary changes of names, but it is not to be expected that a rapidly growing science like taxonomy can be for long conducted with an unchanging set of tools. Nomenclature will become stable only when monographs of high quality have been produced, based on all possible material, bibliographic sources, and techniques, and even these cannot be expected to stand indefinitely against new information and conceptions.

Dr. Smith criticizes the attitude of certain non-taxonomists as follows: "Too many criticisms of the present Rules of Nomenclature are based upon the assumption that professional systematists are playing a malicious game which has no relation to the biological sciences. The authors of these criticisms tacitly assume that systematists already have reached all the conclusions necessary regarding the classification of plants and animals, and that only their innate perversity prevents them from publishing a final and immutable list of the "correct" names of all living things. Immutability is not to be found in science, least of all in a virile branch like systematics, which builds upon facts disclosed by many other disciplines, each of which in itself is vigorous and, as human endeavor goes, young."

Systematists can find many reasons for wanting to reduce to a minimum the changes of scientific names, but this does not mean that absolute stability is the principal goal of systematics or of nomenclature. The goal of systematics is to discover the relationships between organisms so they may be classified in a usable system. The goal of nomenclature is to provide a method of designating the organisms explicitly, with as much uniformity and permanence as the growth of the classification permits. Any proposal that rates stability ahead of the advancement of the science of systematics or the development of one of its myriad components is a backward step and one doomed to ultimate failure and discard.

BOTANY.—*Studies in* Lonchocarpus *and related genera, IV: The* Lonchocarpus rugosus *complex and additional Middle American species.*[1] FREDERICK J. HERMANN, U. S. Department of Agriculture.

In Part II of this study (Journ. Washington Acad. Sci. **38**: 11–14. 1948) an attempt was made to dispose of the various species of *Lonchocarpus* described from Middle America since the publication in 1917 of Pittier's monograph of the species known from that area. Because of lack of herbarium material, however, 17 of these names could not at that time be taken into consideration. Specimens of 10 of these have subsequently become available, through the courtesy of Dr. C. L. Lundell and of the Chicago Natural History Museum, and the result of their study is presented herewith. Several of the names prove to be referable to the protean *L. rugosus* Benth., so a brief discussion of the variations exhibited by that species is appended.

Lonchocarpus apricus Lundell, Lloydia **2**: 90. 1939 = L. RUGOSUS Benth., Journ. Linn. Soc. **4**: 92. 1860; Standley & Steyermark, Fieldiana, Botany, **24**(5): 283–284. 1946.

It was not found possible to correlate with other characters the "numerous approximate lateral veins of the leaflets" by which *L. apricus* was originally set off from *L. rugosus* and *L. hintoni*, nor is this character constant or of geographical significance. Further "differences in pubescence flower size, number of ovules, and leaf form" ascribed to the plant were not detected except in so far as the cited material showed a somewhat more appressed pubescence than most of the collections from Campeche where Bentham's type originated. This, however, is clearly a tendency only and is apparently an ecologic response rather than the result of geographic factors.

Lonchocarpus belizensis Lundell, Wrightia **1**: 55. 1945 = L. LUTEOMACULATUS Pittier, Contr. U. S. Nat. Herb. **20**: 64. 1917.

Although the petals of *L. belizensis* are described in the original description merely as dark red, the standard shows a well-defined yellow area in the center. This and the large size of the standard indicate that the alliance of the plant is with *L. luteomaculatus* rather than with *L. latifolius*.

Pittier's key (Contr. U. S. Nat. Herb. **20**: 51–52. 1917) does not satisfactorily separate *L. latifolius* from *L. luteomaculatus*. One of the few reliable differences between the two appears to be in the shape of the pods. In *L. latifolius* these are elliptic and pointed at both ends; in *L. luteomaculatus* they vary from almost circular to oblong with rounded ends. The length of the standard (6 mm in *L. latifolius*, 10 mm in *L. luteomaculatus*) also seems to be constant. *L. latifolius* frequently has a yellow-centered standard like that of *L. luteomaculatus* but when it does it is a less well-defined "spot" or area and shades off into the red background. The inflorescence in *L. latifolius* tends to be in the form of simple racemes in the upper leaf axils; in *L. luteomaculatus* the racemes are more often compound, or the upper internodes are so greatly shortened that the numerous racemes become crowded and appear to be fastigiate and terminal or nearly so, and at times the inflorescence actually becomes a terminal panicle.

Lonchocarpus chiapensis Lundell, Wrightia **1**: 152. 1946 = L. PENINSULARIS (Donn. Smith) Pittier, Contr. U. S. Nat. Herb. **20**: 56. 1917.

The specimen (*Inst. Fis. Geogr. Costa Rica 13966*) from which the characteristics of the fruit in Pittier's description of *L. peninsularis* were drawn (Contr. U. S. Nat. Herb. **20**: 57. 1917) has ovate, 1-seeded pods only (and these, incidentally, are decidedly overripe, hence the "remarkably recurved carinal margin" which is consequently an infrequently seen condition). Plants with oblong, 2- and 3-seeded legumes are also common, and often both types are found in a single inflorescence as in the type of *L. chiapensis* (*Matuda 5008*). A similar situation obtains in *L. luteomaculatus*. The leaflets in *L. chiapensis* are conspicuously punctate, a characteristic omitted from the original description. In other respects, as well, the type collection closely matches authentic material of *L. peninsularis*.

Lonchocarpus cruentus Lundell, Wrightia **1**: 55. 1945 = L. SERICEUS (Poir.) HBK. Nov. Gen. & Sp. **6**: 383. 1823.

The type of *L. cruentus* has the nerves on the

[1] Received June 15, 1948.

upper surfaces of some of the leaflets as strongly impressed as any to be found in *L. sericeus*. Truly impressed nerves in *L. sericeus*, however, are not the prevailing condition; only in unusual cases can they be said to be plainly impressed. The one difference detected between *L. cruentus* and the prevalent form of *L. sericeus* was in the calyx length of 2.5–4 mm, rather than 5 mm, but the form with shorter calyx not infrequently turns up elsewhere, as in *Eggers 1432* from Trinidad (calyx 3 mm long).

Lonchocarpus gillyi Lundell, Wrightia **1**: 56. 1945 = L. RUGOSUS Benth., Journ. Linn. Soc. **4**: 92. 1860.

Leaflet size appears to be an altogether unreliable diagnostic feature in *L. rugosus*. In the majority of instances they may be larger in that species than are those in the form proposed as *L. gillyi*, yet in some specimens of otherwise typical *L. rugosus* they are even smaller. The fact that the racemes are borne on the old wood in the type of *L. gillyi* is taxonomically meaningless. Among others *Matuda 4020*, referred by the author of *L. gillyi* to his *L. apricus*, likewise has the racemes borne on the old wood; and the type of *L. hidalgensis* Lundell has inflorescences on both the old and the new branches.

Lonchocarpus hidalgensis Lundell, Wrightia **1**: 153. 1946 = L. RUGOSUS Benth., Journ. Linn. Soc. **4**: 92. 1860.

The purportedly distinguishing character of axillary racemes in *L. hidalgensis* is found also in *L. gillyi;* in the Chicago Natural History Museum sheet of *Lundell 857*, referred by its collector (Lloydia **2**: 92. 1939) to typical *L. rugosus*, and in *Matuda 4525*, referred in the same paper to *L. apricus*. Other peculiarities characterizing *L. hidalgensis* represent variations too unstable to merit nomenclatorial recognition.

Lonchocarpus hintoni Sandwith, Kew Bull. Misc. Inf. 1936: 4. 1936 = L. RUGOSUS var. **hintoni** (Sandwith) comb. nov.

This appears to be the only variant of *L. rugosus*, of the several recently proposed as specifically distinct, deserving of taxonomic status. So far as known, it is geographically segregated in the Mexican States of Michoacán, Guerrero, and México, and is distinguished from typical *L. rugosus* by the cinereous strigosity of the leaves (except the upper surfaces of the leaflets which tend to be glabrous and shining at maturity)and inflorescence, this being especially pronounced on the pods which are firmer and more coriaceous than in other forms, and by flowering before the leaves expand. These characteristics are striking in their extreme form, particularly in flowering or fruiting specimens, but they show considerable variation and sterile material very often is decidedly intermediate.

The locality cited for the Langlassé collection (*No. 108*) in the original description of *L. hintoni* apparently is in southeastern Michoacán rather than in Guerrero.

Lonchocarpus nicaraguensis Lundell, Wrightia **1**: 154. 1946 = L. PENINSULARIS (Donn. Smith) Pittier, Contr. U. S. Nat. Herb. **20**: 56. 1917.

The nonimpressed nerves and the clearly punctate leaflets (the latter feature, however, not noted in the original description) of the type material of *L. nicaraguensis* may well have been the reason for its affinity having been surmised to be with *L. michelianus* rather than with *L. peninsularis*. The misplacement of the latter species in Pittier's key (Contr. U. S. Nat. Herb. **20**: 51, where it is placed under section *Spongopteri* of series *Impressinervi* instead of under section *Punctati* of series *Planinervi*) was the apparent cause of the proposal of at least two other synonyms, *L. kerberi* Harms and *L. purpusii* Brandegee (cf. Journ. Washington Acad. Sci. **38**: 13. 1948), of this common species.

Lonchocarpus phlebophyllus Standl. & Steyerm., Field Mus. Publ. Bot. **23**(2): 56. 1944.

This appears to differ from *L. eriocarinalis* Micheli only in its apparently consistently 5-leaflets (rather than 7–11) with more numerous nerves. The vein-number has proved to be of negligible diagnostic value in the closely related *L. rugosus*, but it is possible that when flowering material of *L. phlebophyllus* has been collected additional characters may be found which could be correlated with the anomalous leaflet number.

Lonchocarpus whitei Lundell, Wrightia **1**: 154. 1946 = L. MINIMIFLORUS Donn. Smith, Bot. Gaz. **44**: 110. 1907.

In the publication of this name no affinity with other species was suggested, but the type

material (in fruit) compares well in all respects with typical *L. minimiflorus*, and *White & Gilly 5367* shows the very short, densely sericeus standard which sets off this species from its allies in the Series *Pubiflori*.

LONCHOCARPUS RUGOSUS Benth.

This is the most plentiful of the Middle American Lonchocarpi. It is also the most polymorphic of all the species in the genus, not only in shape, size and venation of the leaflets, in vesture and in stipule characteristics but also strikingly so in its pods. Consequently its variations include much greater extremes than those that have been singled out as the bases for most of the recently proposed segregates. On the basis of a single character most of the specimens may be readily assorted into two groups, but the substitution of a second, equally well-marked, characteristic results in a very different composition of the two groups. Furthermore, as soon as a correlation is attempted between two or more of the differentiating features (with the single exception of var. *hintoni*), the number of recalcitrant intermediates becomes disconcerting, as has been pointed out by Standley and Steyermark in their discussion of *L. apricus* (Fieldiana, Botany, **24**(5): 284. 1946).

Among the most outstanding forms of the species are those characterized by divergence in type of pubescence. A copious, shaggy type of villosity found in combination with very large (9×2.5 cm), few-nerved leaflets and large, widely divaricate, persistent stipules in *Steyermark 45744* from Guatemala is so striking that this plant at first appears to have little in common with *L. rugosus*. This villosity reappears in a similarly pronounced degree in *Schipp 503* from British Honduras, but is here associated with small, ascending caducous stipules and moderately nerved leaflets of average size (4×2 cm). Between this overdeveloped villosity and the prevalent form with short, only moderately dense villosity, an extensive series of transitional stages is found in innumerable combinations with other characters. In other collections the vesture fluctuates toward either of two additional extremes; a dense tomentum in such individual plants as *Hinton 6325* from Mexico and *Steyermark 51554* from Guatamala, or a comparatively sparse strigosity represented by *Standley 19254* from El Salvador.

A similarly extensive range of fluctuation is evident from a comparison of the legumes, from the standpoint of their shape, size, texture, type of pubescence or number of seeds; of the leaflets, from the standpoint of number, size, texture, venation, or type of apex or base; or of the characteristics of the inflorescence. And in each case a similar lack of consistency, a refusal to submit to the taxonomist's penchant for pigeon-holing, will be noted.

Extensive field acquaintance with *Lonchocarpus rugosus* would doubtless be helpful in suggesting explanations for its seemingly unpredictable behavior. From herbarium evidence alone conjectures are risky, but it seems not altogether improbable that frequently sufficient allowance has not been made for the influence of environmental factors upon the species, since it is not only one of the most widely distributed of the Lonchocarpi but is to be found in a greater diversity of habitats than the majority of its congeners.

BOTANY.—*New species of* Salix *from Szechwan, China.*[1] WEN-PEI FANG, National Szechwan University, Chengtu, Szechwan. (Communicated by EGBERT H. WALKER.)

The four new species of willows described herein were found among the numerous collections that have been made in Szechwan Province, China, in recent years. The types are deposited in the herbarium of the National Szechwan University at Chengtu. Duplicates are being distributed to various herbaria in China and the United States.

[1] Received April 22, 1948.

1. **Salix triandroides** Fang, sp. nov.

Frutex parvus, 2 m altus, cortico laevi, flavescenti- vel fusco-cinereo. Ramuli erecti, cylindrici, hiemales dense nigrescenti- vel fusco-tomentosi, vernales glabrescentes. Gemmae ovoideae, 8 mm longae, perulis late ovatis extrinsecus dense cinereo-tomentosis. Folia alterna, chartacea, glabra, lanceolata vel oblanceolata, rarius oblongo-ovata vel oblongo-obovata, 3–5 cm, rarius ad 12 cm longa, 1–1.5

cm, rarius ad 2.2 cm lata, apice caudato-acuminata vel breviter acuminata, basi late cuneata, margine glanduloso-serrulata, supra atroviridia, subtus pallidiora; costa media supra obscura subtus prominens; nervi laterales utrinsecus 5–20, obsoleti; petioli cylindrici, 8 mm longi, glabri, supra canaliculati, subtus rotundati. Flores coetanei, amenta mascula 2–2.5 cm, rarius ad 3 cm longa, flava vel viridi-flava, densiflora, rhachi albo-pilosa et albo-pubescente; pedunculi 5–8 mm longi, pubescentes, foliis 2 vel 3 suffulti; bracteae flavae vel fusco-flavae, obovatae, 2 mm longae, utrinque pilosae. Stamina 3, filamentis gracilibus 3 mm longis basi villosis, antheris flavis ovalibus, glandula ventrali simplici flava oblongo-conicali, glandula dorsali simplici flava oblonga. Amenta feminea alterna, 2.5–3 cm longa, viridia, densiflora, rhachi cinereo-pubescenti vel pilosa; pedunculi 1–1.5 cm longi, foliis obovatis 2 vel 3 suffulti; bracteae flavescenti-virides, oblongae, 2–3 mm longae, extrinsecus albo-pilosae, intrinsecus glabrae; ovaria conico-ovoidea, 5 mm longa, viridia, glabra; pedicelli 1–1.5 mm longi, glabri; stylus brevior; stigmata divergentia; glandula ventralis flava, oblongo-ovoidea. Amenta fructifera 3–3.5 cm longa, capsulis conico-ovoideis 5 mm longis flavescenti-viridibus: bractea extus albo-pilosa; pedicelli 1–1.5 mm, longi, tenues, glabri.

East of Chengtu: Tsing-chu-ssu, *W. P. Fang 19427* ♀, *19598* ♂, *K. Y. Ning 7660* ♂; Kuan-ying-chiao, *W. P. Fang 19411* ♂; Wu-kuai-chiao, *K. Y. Ning 7910* ♀, *7918* ♀. Southeast of Chengtu: Near Wang-kiang-lau, *K. Y. Ning 7953* ♂, *7954* ♂, *7955* ♂; campus of National Szechwan University, *W. P. Fang 19604* ♀, *19605* ♀, *19605A* ♂, *19606* ♂, *19608* ♂, *19611* ♀, *19617* ♀; T'ou-wa-you, *W. K. Hu 7694* ♀, *7695* ♀, *W. P. Fang 19376* ♀, *19416* ♀, *19415* ♂, *19417* ♂, *19418* ♂, *K. Y. Ning 7917* ♂, *7938* ♂, *7939* ♂; Chung-shu-chiao *W. K. Hu 7633* ♂, *7639* ♂; Kao-pan-chiao, *W. P. Fang 19370* ♂, *19379* ♂, *19383* ♀, *19385* (type) ♀, *19435* ♀, *19516* ♀, *19637* ♀. South of New Village of Chengtu: *W. P. Fang 19322* ♀, *19393* ♂, *19440* ♀. West of Chengtu: Chia-tien-tzu, *K. Y. Ning 7962* ♂. Northwest of Chengtu: Tu-chu-miao, *K. Y. Ning 7947* ♂, *7848* ♂.

This new species is nearly always found by a stream, occasionally by the roadside. All the cited specimens were collected in the month of March, 1945–1947, except *K. Y. Ning 7917* and *7933*, staminate specimens collected on February 16, 1946. Fruiting specimens may be found late in March.

This species is quite distinct from all the known species. It may be near *Salix triandra* L., from which it differs in its shrubby habit with blackish-gray, densely tomentose branchlets in winter, in its short staminate catkins with oblanceolate bracts which are pilose on the outer surface, in its pistillate catkins with glabrous ovaries and oblanceolate bracts which are longer than the pedicels, and in the lanceolate leaves which are pale green but not glaucous below. *Salix triandra* L. is widely distributed in Europe, northern Asia, and northern Africa, but in China it occurs only along the eastern coast from Manchuria to Kiangsu. This new species is fairly common along the streams in the vicinity of Chengtu. The young leaves of the flowering branchlets are ovate or obovate, but adult ones on the leafy branches are usually lanceolate, and those from the stout branches are exceptionally large in size.

2. **Salix neowilsonii** Fang, sp. nov.

Arbor 6–15 m alta, cortice fusco-cinereo sulcato. Ramuli erecti, teretes, graciles, glabri; hornotini purpureo-virides, annotini fusco-virides vel pallido-virides. Gemmae conoideae, 6 mm longae, perulis late ovatis fuscis pubescentibus; bracteae 2, obovatae, membranaceae, fusco-virides. Folia alterna, chartacea, glabra, lanceolata, 6–14 cm longa, 2.5–4 cm lata, apice acuminata vel abrupte acuminata, basi cuneata, margine adpresse glanduloso-serrulata, supra atroviridia, subtus pallidiora, costa media supra distincta, subtus prominente, nervis lateralibus utrinsecus 25–30 obsoletis; petioli graciles, 1–2 cm longi, supra canaliculati, primum pubescentes et purpurescentes, adulti glabri et virides, tandem rubri, apice 2- rarius 4-glandulosi; stipulae deciduae. Flores coetanei; amenta mascula viridi-flava, cylindrica, 3.5–4.5 cm, rarius ad 6.5 cm longa, laxiflora; rhachis albo-pubescens; pedunculi 7–10 mm longi, albo-pubescentes, foliis 2–6 suffulti; bracteae oblongae, 2 mm longae, flavescenti-virides, extrinsecus sparse pubescentes, intrinsecus pubescentes et margine ciliatae. Stamina 3–5, inaequalia, plerumque 2 longiora circa 4 mm longa, 3 breviora circa 2 mm longa; filamenta gracilia, sursum glabra, basi villosa; antherae subovoideae, flavae, glandulis ventralibus et

dorsalibus flavis pseudodiscum formantibus. Amenta feminea et fructus ignoti.

East of Chengtu: Near Tsing-chu-ssu, *W. P. Fang 19403* (type). Southeast of Chengtu: Wang-kiang-lau, near Lei-shun-miao, *K. Y. Ning 7956*, *W. P. Fang 19616*, *19628*, *19378*, *19405;* campus of National Szechwan University, *W. P. Fang 19414*, *19610;* T'ou-wa-you, *K. Y. Ning 7931*, *7932*, *7934*, *W. P. Fang 19414:* near the Arsenal, *K. Y. Ning 7937*, *W. P. Fang 19433*, *19434;* Kao-pan-chiao, *K. Y. Ning 7948*. South of Chengtu: Outside the new south gate, *W. P. Fang 19390;* Hua-hsi-pa, *W. P. Fang 19390A*. West of Chengtu: Tsing-young-kon, *K. Y. Ning 7981;* Tao-chu-miao, *K. Y. Ning 7949;* Cha-tien-tzu, *K. Y. Ning 7964;* King-niu-pa *K. Y. Ning 7972*, *7976*. Northwest of Chengtu: Chiang-chun-pao, *K. Y. Ning* 7981; Chung-cheng Memorial Park of Chengtu, *W. P. Fang 19634* (cultivated). Southwest of Chengtu: Pei hua-tan, *W. P. Fang*, *12041*, *13272*.

This new species is closely related to *Salix wilsonii* Seemen but is separated easily from that species by the branches and leaves which are glabrous even during the young stage, by the petioles which are provided with 2 or 4 glands near the apex, and by the oblong bracts which are pubescent on the inner surface. Although we have not yet found the pistillate flowers, the material on hand is sufficient to indicate an undescribed species. The tree is usually cultivated as an avenue-tree in the vicinity of Chengtu.

3. **Salix hsinhsuaniana** Fang, sp. nov.

Frutex 1 vel 2 m altus, cortice nigrescenti-cinereo laevi. Ramuli graciles, teretes; hornotini pubescentes; annotini glabrescentes, purpureo-virides. Gemmae conicae, fusco-purpureae, glabrescentes. Folia decidua, alterna, chartacea, elliptica vel elliptico-oblonga vel elliptico-oblanceolata, 2–2.5 cm longa, 8–10 mm lata, apice obtussa vel subrotundata, basi obtusa vel late cuneata, margine integra, supra atroviridia, glabra, costa media puberula excepta, subtus viridia, juvenilia sparse tomentosa vel villosa, maturitate glabrescentia; costa media supra depressa subtus conspicua; nervi laterales utrinsecus 8–10 supra obsoleti, subtus conspicui; petioli 2–3 mm longi, juveniles pubescentes, maturitate glabri. Flores serotini; amenta masculina fusco-flava, densiflora, cylindrica, 2–2.5 cm longa, 7 mm crassa, rhachi albo-villosa; pedunculi 1–1.2 cm longi, pubescentes, foliis normalibus 3–4 suffulti. Stamina 2 plerumque 3 mm longa; filamenta gracilis, glabra nisi ad medium villosum; antherae subglobosae, fusco-purpureae; bracteae ovatae, 0.8 mm longae, glabrae, margine ciliatae; glandulae ventrales purpurescenti-flavae, oblongae, plerumque 0.2 mm longae. Amenta feminea densiflora, cylindrica, 3–4 cm longa, 6 mm crassa, rhachi villosa; pedunculi 1–1.5 cm longi, cinereo-villosi, foliis normalibus 2–3 suffulti; ovaria sessilia longo-conico-ovoidea, 2 mm longa, fusca, glabra, stylis gracilibus 2-lobatis, stigmate subcapitato; bracteae suborbiculares, 0.4 mm longae, glabrae, margine sparse ciliatae; glandulae ventrales flavae oblongae, quam bracteae breviores. Capsulae sessiles, 5 mm longae.

Szechwan: Mount Omei: Chin-ting, alt. 3135 m, *H. C. Chow 7670* June 27, 1938 (pistillate flower, type); en route from Chin-ting to Chien-fu-ting, alt. 3150, common in thickets, *C. L. Sun 445*, June 10, 1939, Chien-fu-ting, alt. 3,150 m, *T. C. Lee 2846*, July 18, 1940 (typical of fruit), *W. P. Fang 19002*, June 18, 1942 (typical of staminate flower).

Sikang: Tien-chun-hsien (formerly known as Mupin), *K. L. Chu 2317*, April 12, 1937.

This new species is near *Salix luctuosa* Léveillé, from which it differs in the bracts of both staminate and pistillate flowers, which are glabrous on both surfaces, although they are ciliate on the margin, and in the ventral glands which are much shorter than the bracts.

This new species is named in honor of Prof. Hsin-hsuan Chung, of the National Wuhan University, under whose direction H. C. Chow made several expeditions on Mount Omei. The pistillate flower is here described from a duplicate set of their collections kindly sent by Professor Chung.

4. **Salix chuniana** Fang, sp. nov.

Frutex 3–5 m altus, cortice nigro-fusco. Ramuli graciles, teretes; hornotini virides vel purpureo-virides, pubescentes; annotini flavescenti-fusci vel nigro-fusci, glabri. Gemmae conicae, 7 mm longae, fuscae, sparse puberulae. Folia alterna, chartacea, lanceolata, basi late cuneata vel subrotundata, margine leviter appresso-serrulata, supra atroviridia, juvenilia sparse pubescentia, maturitate glabrescentia,

costa media pubescenti excepta; nervi laterales plerumque obsoleti; folia subtus cinerescenti-viridia, leviter glauca, flavescenti- vel albo-sericeo-tomentosa; costa media prominens; nervi laterales utrinsecus 11–13, conspicui, incurvati; petioli graciles, 5–8 mm longi, supra canaliculati, subtus rotundati, tomentosi vel pubescentes. Flores serotini; amenta masculina ignota; amenta feminea laxiflora cylindrica, 4.5–5 cm longa, 4 mm lata, basi efoliosa; rhachis pubescens; pedunculi 5–7 mm longi albo- vel flavescenti-pubescentes; bractae oblongo-ovatae 0.5–0.8 mm longae, utrinsecus albo- vel flavescenti-sericeo-tomentosae; ovaria subsessilia, conico-ovoidea, 2 mm longa, sparse glandulosa ad basin et plerumque sparse villosa, stigmate 3- vel 4-lobato, glandula ventrali flava, lineari, 1 mm longa, plerumque quam bractae longiore ovarium medium aequante. Fructus subsessilis; capsula 5 mm longa sparse villosa.

Szechwan: Mount Omei: Tsuan-tien-po, alt. 2000 m, in thickets, *C. L. Sun* 284 (type); Opien-hsien, Wa-shan, in forests, *C. L. Sun* 1073; Mount Omei, *W. C. Cheng 10314*, *C. W. Yao 2315*, *2345*, *3866*.

All were pistillate specimens collected in May except *Sun 1073* in fruit collected in August.

Although the staminate flower has not been seen, this is a very distinct new species in the section *Chingianae* Hao. It is near *Salix rehderiana* Schneider in general appearance but differs in the habit of flowering after the leaves and in the pedunculate long and narrow pistillate catkins, which are leafless at the base. The flowers of *Salix rehderiana* are precocious and the sessile catkin is just 2.5 cm in length and 8 mm in width, and provided with two or three normal lanceolate leaves at the base of the inflorescence.

This new species is named in honor of my former teacher, Prof. Woon-Young Chun, the founder of the Botanical Institute of the National Sun Yatsen University at Canton, and the leading systematic botanist in China, for his unceasing devotion to floristic investigation and his encouragement to young botanists.

ENTOMOLOGY.—*Two new Ithomiinae in the Schaus collection (Lepidoptera: Nymphalidae)*.[1] Richard M. Fox, Pittsburgh, Pa. (Communicated by E. A. Chapin.)

The two butterflies described here are from the collection of the late Dr. William Schaus, which is now part of the United States National Museum collection of Lepidoptera. A few years ago the writer was invited by Dr. Schaus to study the ithomines he had accumulated, and through the courtesy of the National Museum and of the Academy of Natural Sciences of Philadelphia was enabled to do so. Some of the species and subspecies discovered among this material already have been published upon.[2]

Pteronymia schausi, n. sp.

This series, labeled "Colombia," approximates *P. tucuna* (Bates),[3] a number of specimens of which I have seen from northern Peru. There are many points of difference, however: The opaque costal spot of the forewing is less brilliantly yellow, is only half as long as in *tucuna*, and is cut off by the brown R_s (this is yellow in *tucuna*). The end of the cell, is yellow-transparent, the base yellow-orange-transparent and R and the cubitus are very narrowly red-tawny. The spots in the transparent areas of the rest of the wing are smaller, more translucent than in *tucuna;* these are located as follows: A yellow-transparent spot beyond the narrow, pointed brown discocellular band, crossing the base of M_1, cut off at M_2; a tiny yellow-white-transparent spot halfway to the margin in M_2-M_3; a series of submarginal whitish-transparent spots R_s to Cu_2, the last of these elongated. The anal border fills the space posterior of cubitus-Cu_2.

The hind wing has an even border, brown-black, 1 to 2 mm wide, the cell and part of the disc toward the anal margin suffused with yellow-orange, the veins here yellow-brown. Between this suffused area and the opaque

[1] Received March 7, 1948.

[2] Fox, R. M. *New Ithomiinae*, Sci. Publ. Reading Public Mus. **2**: 34 pp., 2 pls. 1941.

[3] Bates, H. W. Trans. Linn. Soc. London **23**: 544. 1862. (São Paulo, Amazons.)

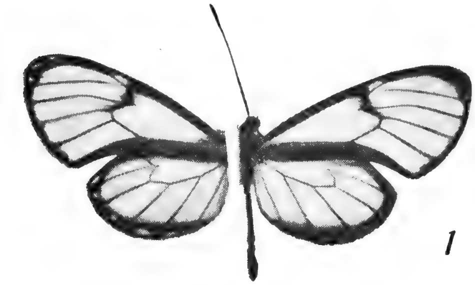
marginal color there is a colorless transparent lunate line traversed by brown veins running from Cu_2 to the wing apex.

Beneath as above, but the borders filled with rusty-tawny; three tiny white admarginal spots in the forewing apex; the hind wing with a series of oval white admarginal spots M_1 to 2A, paired Cu_2-2A; costal margin rusty-tawny, the humeral angle yellowed.

Antennae black with orange-brown clubs; thorax black-brown with white scaling; abdomen brown above, yellow beneath.

Type.—Male; Colombia; coll. Wm. Schaus; U.S.N.M. no. 58560.

Paratypes.—5 males, same data; 2 Academy of Natural Sciences of Philadelphia, 2 U. S. National Museum.



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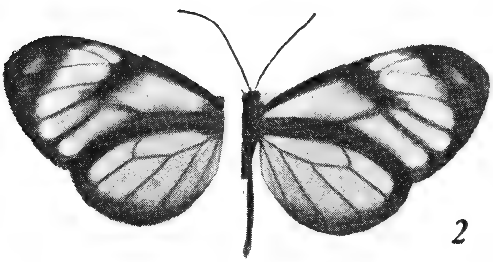

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Fig. 1.—*Pteronymia schausi,* n. sp.: Type male, from Colombia; collection William Schaus.
Fig. 2.—*Hypoleria meridana,* n. sp. Type female, from Mérida, Venezuela. (Detached wings on left are under sides; wings on right are upper sides.)

Hypoleria meridana, n. sp.

This is related to *H. vanilia* (Herrich-Schäffer)[4], and might be taken for an aberrant individual. The postdiscal dark band is placed farther apicad, however, reducing the size of the subapical transparent spots R_s to M_2 and eliminating entirely the one in M_2-M_3. The white discal band is stronger; the tawny on the hind wing is reduced to a narrow edging on the proximal side of the border between Cu_1 and 2A. The white band of the forewing crosses R_s, M_1, and M_2, whitening these veins proximad and nearly filling the cells between the discocellular band and the postdiscal band, entirely filling M_3-Cu_1, although M_3 is narrowly black.

In other respects the colors and markings are exactly as in *H. vanilia,* of which this may be relegated eventually as a subspecies.

Type.—Female; Mérida, Venezuela; U.S.N.M. no. 58561.

[4] Herrich-Schäffer, G. A. W. Corr.-Blatt. Regensburg **18:** 175. 1864. (New Grenada.)

ZOOLOGY.—*A new subspecies of tree frog from Pernambuco, Brazil.*[1] Doris M. Cochran, U. S. National Museum.

While studying the small hylas of Brazil, I noted differences between examples of *Hyla bipunctata* Spix from the state of Rio de Janeiro and four Pernambuco examples received from Dr. Thomas Barbour likewise identified as *bipunctata.* The Museum of Comparative Zoology kindly lent 16 additional frogs of the original series from Pernambuco. Their characters are stable enough to warrant their description as a new subspecies.

Hyla bipunctata branneri, n. subsp.

Diagnosis.—Closely related to *Hyla bipunctata* Spix, differing from it mainly in the absence of the purple areolate pattern on the sides of the snout, in the presence of a single silvery-white spot under the eye, in a less pronounced dorsal pattern, and apparently in smaller adult size (21.5 mm for ♀, 18 mm for ♂ in *branneri,* compared to 25 mm for ♀, 25.5 mm for ♂ in typical *bipunctata*).

Type.—U.S.N.M. no. 48861, an adult female from Bonito, Pernambuco, Brazil, collected by J. C. Branner for the Museum of Comparative Zoology, and donated to the U. S. National Museum in 1912. Paratypes: U.S.N.M. Nos. 48862–4 and M.C.Z. nos. 2827A–P, all with the same data as the type.

Description of the type.—Vomerine teeth in two small, well-separated patches between the choanae; tongue a little more than half as wide

[1] Received May 12, 1948.

as mouth-opening, rounded, notched and slightly free behind; snout short and rounded when viewed from above, truncate in profile, the upper jaw extending only slightly beyond the lower; nostrils superolateral, projecting, their distance from end of snout about one-third that to anterior border of eye, separated from each other by an interval equal to their distance from eye. Canthus rostralis not well defined, merging with the loreal region which is flat. Eye large, prominent, its diameter equal to its distance from end of snout; interorbital diameter about $1\frac{2}{3}$ times the width of upper eyelid, greater than distance between nostrils. Tympanum distinct, about one-third the eye diameter, separated from eye by an interval equal to two-thirds its own diameter. Fingers one-third webbed, fourth considerably longer than second; disk of third finger just covering tympanum; no rudiment of a pollex visible; toes three-fourths webbed, third a little longer than fifth; disk of fourth toe covering tympanum; a distinct, projecting inner metatarsal tubercle, but no outer one; no true tarsal ridges or heel appendages; metacarpal and metatarsal tubercles present. Body somewhat elongate, in the postaxillary region slightly narrower than greatest width of head; when hind leg is adpressed, heel reaches to nostril; when limbs are laid along the sides, knee and elbow touch; when hind legs are bent at right angles to body, heels considerably overlap. Skin of upperparts nearly smooth, with small pustules on shoulders and back of head; no pronounced ridge encircling upper part of tympanum; skin of throat and chest smooth in the female; in the male the throat is finely plicate because of the large vocal sac which covers the center and sides of the throat; skin of belly coarsely granular, that of posterior femur and anal region less heavily granular. A skin fold across the chest.

Color (in alcohol): Dorsum pinkish vinaceous to fawn color; a light-brown cross bar between the eyes, followed by a pale)(-shaped mark on the back extending to the sacral region. A metallic white mark below the eye extending to the upper lip border; remainder of upper lip finely punctate with gray dots, but with no alveolar pattern like that found in *bipunctata;* a wide dark canthal line edged narrowly with white above, continuing behind the ear and along the side of the body where it becomes less distinct as it approaches the groin; femur immaculate; upper surface of tibia with faint darker markings.

Variations: The white spot below the eye is very prominent in 18 of the 20 specimens at hand; in the remaining 2 it is somewhat reduced. The heel reaches from between center of eye to tip of snout, most often to nostril. In 3

TABLE 1.—MEASUREMENTS OF 20 SPECIMENS OF HYLA BIPUNCTATA BRANNERI, N. SUBSP.

Specimen	Sex	Total length	Head length	Head width	Femur	Tibia	Foot	Hand	% Head length	% Head width	% Femur	% Tibia	% Foot	% Hand
U.S.N.M. 48861	♀	21.5	6.5	6.5	10.5	11.5	9	5.5	30.2	30.2	48.8	53.4	41.9	25.6
48862	♀	20	5.5	6	9.5	11	8.5	6	27.5	30.0	47.5	55.0	42.5	30.0
48863	♀	19	6	6.5	9	11	8	6	31.6	34.2	47.4	57.9	42 1	31.6
48864	♀	14.5	4.5	5	7	7.5	5.5	4	31.1	34.5	48.3	51.8	37.9	27.6
M.C.Z. 2827 A	♀	18	6	6.5	9	10	8	5.5	33.3	36.0	50.0	55.5	44.5	30.5
2827 B	♀	16.5	5	6	8	9	7	4.5	30.3	36.4	48.5	54.6	42.5	27.3
2827 C	♂	17	5.5	5.5	8	8.5	7	5	32.4	32.4	47.1	50.0	41.2	29.4
2827 D	♀	19	6.5	6	9	9.5	8	5.5	34.2	31.6	47.4	50.0	42.1	29.0
2827 E	♂	17	5	5.5	8	8	7.5	5	29.4	32.3	47.1	47.1	44.1	29.4
2827 F	♂	17	5	5.5	8	9	7.5	5	29.4	32.3	47.1	53.0	44.1	29.4
2827 G	♂	16	5	5.5	7.5	8	7	4.5	31.3	34.3	46.9	50.0	43.8	28.1
2827 H	♀	19.5	6	6	9.5	10.5	7.5	5.5	30.8	30.8	48.7	53.9	38.5	28.2
2827 I	♂	17	5.5	5.5	8	9	7	5	32.3	32.3	47.1	53.0	41.2	29.4
2827 J	♂	16.5	5.5	5.5	7.5	8	7.5	4.5	33.3	33.3	45.5	48.5	45.5	27.3
2827 K	♂	16	5.5	5.5	8	9	7	5	34.3	34.3	50.0	56.2	43.8	31.3
2827 L	♂	17.5	5.5	5.5	8	9	7	5	31.4	31.4	45.7	51.4	40.0	28.6
2827 M	♀	17.5	5.5	5.5	9	10	7.5	5	31.4	31.4	51.4	57.2	42.9	28.6
2827 N	♂	16	5	5.5	8	9	7	5	31.3	34.3	50.0	56.2	43.8	31.3
2827 O	♂	18	6	6	7.5	9	6.5	5	33.3	33.3	41.6	50.0	36.0	27.8
2827 P	♂	17	5.5	5.5	8	8.5	8	4.5	32.3	32.3	47.1	50.0	47.1	26.5
					N = 20			M =	31.6	32.8	47.7	52.7	42.3	28.8
								σ =	1.66	1.73	2.01	2.98	2.31	1.57
								V =	5.3	5.3	4.2	5.7	5.4	5.3
								σm =	0.37	0.39	0.45	0.67	0.52	0.35

specimens no dorsal pattern was visible; in 3, faint mottlings appeared; in 2, scattered spots occurred, while in the remaining 12, the)(-shaped pattern found in the type was fairly apparent.

ZOOLOGY.—*American Caudata IV: Allocation of the name* Bolitoglossa mexicana.[1] M. B. MITTLEMAN and HOBART M. SMITH. (Communicated by HERBERT FRIEDMANN.)

The most recent discussion (Smith, Herpetologica **3:** 17. 1945) of *Bolitoglossa mexicana* Duméril, Bibron, and Duméril 1845 (Erp. Gen. **9:** 93, pls. 104. 1845) concludes by allocating the name with *B. platydactyla* Gray, an earlier (1831) name. This action was based chiefly upon Brocchi (Miss. Sci. au Mexique, Batr., livr. 3: 113, pl. 18 bis. 1883), who illustrated four specimens, presumably cotypes of *mexicana,* one of which was indicated as "type," while each of the others was called "variété." All were stated to be from Veracruz, where only *platydactyla* (of the involved species) occurs.

In reality, as discovered by the senior author, the locality citation in the plate explanation is obviously in error. On page 114 Brocchi clearly selects (from the extraordinary mixture of specimens of *bellii, platydactyla,* and a species from Petén, Guatemala, that together comprise the cotypes of *B. mexicana*) the two Petén specimens as types. Brocchi's text may be translated literally as follows (1883: 114):

Coloration.—The coloration varies considerably. In the type, the body is a uniform reddish brown; the same coloration is found on the upper parts, but there may be made out numerous spots of a distinct light hue. These spots, which are orange, are disposed to form three longitudinal and parallel bands in one of the examples sent by M. Morelet, and form a kind of mantle in the other specimen; in this latter, there are on the surface of the mantle a number of spots which again show the basic reddish brown color (figs. 3 and 4).

That Brocchi in this discussion actually selected one of the two as the type is debatable, but he may be considered to have clearly indicated his type through a combination of the above text, plus the legend to his plate 18 bis, and figure 3 of this plate, which the legend designates as the type from "Vera Cruz." This figure exactly matches the description for the first Morelet specimen ("These spots, which are orange, are disposed to form three longitudinal and parallel bands in one of the examples sent by M. Morelet."). Brocchi's reference to figures 3 and 4 in the passage quoted above, as well as his ascribing a Veracruzan origin to the type, figure 3, in the accompanying legend, seems explainable as a simple *lapsus.* That this is the case is borne out by comparing his figure 4 with his description of "Variété I," which fits the figure very well. This specimen is listed, under "Variété I," as coming from "Mexico" (although the plate legend states "Vera Cruz"), and of it Brocchi says, "it is a dark gray, and not reddish brown as in the specimens of M. Morelet. All of the upper surface of the body and tail is covered with an orange mantle, the surface of which has a few dark gray spots." Brocchi thus succinctly summarizes the difference between this specimen and that figured above it on the same plate (figure 3).

Figure 1 of Brocchi's plate is listed on the legend as being from "Vera Cruz," and is similarly cited in his discussion of "Variété II," which almost certainly refers to the specimen illustrated as figure 1, since the discussion states that the specimen—unlike the others shown—has distinct orange maculations on its limbs, and the delineation in figure 1 clearly shows this. Figure 2 of the plate is described in Brocchi's text under "Variété III." The description given there fits the figure perfectly, even to the strongly annulated tail shown in the plate, and which Brocchi specifically mentions as "les annulations de la queue sont tres marquées (fig. 2)."

Figures 1, 2, and 4 of Brocchi's plate 18 bis are clearly *Bolitoglossa platydactyla.* Figure 3, although described in the plate legend as being from "Vera Cruz," is clearly associated through textual reference with one of those sent to Duméril, Bibron, and Duméril by Morelet from Dolores, Ptéen, Guatemala. Moreover, the specimen described by Brocchi as the first of the two sent by Morelet, and which we believe is

[1] Received June 4, 1948.

depicted in figure 3 of Brocchi's plate, is described by the original authors in much the same terms: " . . . in the other, these spots are united to form two black bands on the trunk, and between these bands there are distributed many spots of the same color." Brocchi of course described three orange bands, while Duméril, Bibron, and Duméril described the dark ground color between the orange bands. In either case, the general effect is the same, namely alternating bands of orange and black.

So far as Brocchi is concerned, then, the conclusion that he validly restricted the name *mexicana* to the Petén species is not reasonably contestable. Even if the word "type" in the plate explanation is construed to mean only "typical" instead of "*the* type"—as indeed is implied by various facts, including citation of the other figures as "variété"—the restriction of the name to at least the *series* from Petén is unequivocal.

Smith's conclusion, on the basis stated, that *mexicana* is a synonym of *platydactyla* is therefore incorrect. On the evidence given it is a valid name for the Petén species and *moreleti* (Smith, 1945) is a later synonym.

If Brocchi's action were the only one to be considered the nomenclature of these species would be clearly evident. Unfortunately, two other factors throw doubt upon the permanence of any conclusion now reached.

First, Duméril et al. (1854, p. 94), after discussing the "Caractéres" of *B. mexicana*, cite the following: "SYNONYMIE. 1838. Oedipus platydactylus? Tschudi, Class. Batrach. p. 93, no. 7." Had the question mark not been included, there is little doubt that this citation could automatically place *mexicana* in the synonymy of *platydactyla*. The question mark actually, however, introduces a situation for which there is no policy recommended by either the Opinions or Rules of the International Commission on Zoological Nomenclature. Moreover the identity of *Oedipus platydactylus* Tschudi is not absolutely clear, inasmuch as he cites a *nomen nudum* (*Salamandra platydactyla* Cuvier) for the source of the specific name, although the genus *Oedipus* (monotypic) was new. One realizes that the reference is to Gray's work (Reptilia, in Griffith's Cuvier's Animal Kingdom, 1831, p. 107), in which "*Salamandra platydactyla* Cuvier" is very briefly described. In reality Cuvier never described the species; Gray was, apparently, accepting the names on certain museum labels of Cuvier. So far as Cuvier is concerned, the name may be considered a *nomen nudum*, although most authors, even a recent monographer of the group (Dunn, Salam. Fam. Plethodontidae, 1926, p. 400) have accepted Cuvier as the author of the name. The point is perhaps academic, but as long as it remains a debatable point the proper allocation of the name *mexicana* remains in doubt.

A second complicating factor is the action of Boulenger in 1882 (Cat. Batr. Grad. Caud. Batr. Apoda Brit. Mus., ed. 2), one year prior to the publication of Brocchi's work. In the synonymy of *Spelerpes bellii* Gray 1850 (p. 68) he cites the following: "*Bolitoglossa mexicana* Dum. & Bibr., p. 93, pl. 104, f. 2." The allocation is correct; certain specimens, including the one whose figure was cited, did belong to *Spelerpes bellii* Gray [=*Pseudoeurycea bellii* (Gray) as of today]. But on page 73 he cites the following in the synonymy of *Spelerpes variegata* Gray [=*Bolitoglossa platydactyla* Gray]: "*Bolitoglossa mexicana*, part., Dum. & Bibr., pl. 104. fig. 1." Actually the figure cited does not belong to *platydactyla*, but to the Petén species. Not until 1936, however, was it realized that the Petén species was different from *platydactyla*; even a recent monographer (Dunn, Salam. Fam. Plethodontidae, 1926, p. 400) was not aware of their distinctness. Whether Boulenger was correct at all, or correct even by the interpretation of his time, in allocation of the cotypes of *mexicana* other than those representing *bellii* is perhaps immaterial; the point is one, again, open for debate since no procedure is specified by taxonomic rules. This is certain: that as the species was then (1882 up to 1936) thought of, all the cotypes of *mexicana*, other than those of *bellii*, were correctly placed by Boulenger with *platydactyla*. The really important action by Boulenger, however, was the inclusion of the word "part" with reference to Duméril et al. under *variegata*, and omission of any qualification in the reference under *bellii*. Does this constitute a restriction of the name to the synonymy of *bellii* by Boulenger? It seems quite possible. Is Bou-

lenger's restriction, if admitted, superseded by Brocchi's?

Until these questions are settled, there is absolutely no certainty whatever of the proper name, under the Rules, for the Petén species. A request has been submitted, accordingly, to the International Commission for a ruling on each of the three chief principles involved on which a decision is necessary prior to definite establishment of the name.

CONCLUSIONS

1. The name *Bolitoglossa mexicana* Duméril, Bibron, and Duméril is not a synonym of *B. platydactyla* because of any action by Brocchi.

2. Said name may, however, possibly be regarded a synonym of *B. platydactyla* on the basis of inclusion of the latter name in the synonymy of *B. mexicana* by Duméril et al.

3. Said name may also, if No. 2 is not true, be regarded a synonym of *Pseudoeurycea bellii*, on the basis of the supposed restriction of that name by Boulenger.

4. Said name, finally, if neither No. 2 nor No. 3 is true, may be regarded as a valid name for the Petén species (of which *B. moreleti* would then be a synonym) on the basis of type designation by Brocchi.

Obituary

Harry Diamond, chief of the Electronics Division of the National Bureau of Standards, died suddenly at his Washington home on June 21, 1948.

Mr. Diamond was born on February 12, 1900, and attended schools in and around Quincy and Boston, Mass. He received his bachelor of science degree from the Massachusetts Institute of Technology in 1922, where he served in the SATC during World War I, and took his master's degree in electrical engineering from Lehigh University in 1925.

After Mr. Diamond joined the staff of the National Bureau of Standards as a radio engineer in 1927, his brilliant scientific achievements led to rapid advancement. He was chief of the Bureau's Ordnance Development Division during the war, and later of the Electronics Division, which now includes the ordnance work. During the five years between graduation from M.I.T. and entry on the bureau staff, he was at first employed by various industrial concerns in the Boston area and later taught for four years at Lehigh University, where he organized the first radio course at the University.

His work at the National Bureau of Standards was diversified, including aviation radio, radio aids to meteorological observations, radio direction finding, electronic ordnance, and general electronics. One of the inventors of the radio proximity fuze (No. 2 secret weapon of World War II), Mr. Diamond was widely honored for his work. Among the acknowledgments he had received were the 1940 Award for Engineering Achievement of the Washington Academy of Sciences; the Naval Ordnance Development Award for Exceptional Service, 1945; and the War Department Certificate for Outstanding Service, 1945. He was a fellow of the Institute of Radio Engineers; a fellow of the American Institute of Electrical Engineers; a division member of the National Defense Research Committee; a panel member of the Joint Research and Development Board; a director of the American Ordnance Association; and a member of the Washington Academy of Sciences and Sigma Xi.

Mr. Diamond played a large part in the development of the Instrument Landing System (ILS) and participated in the first completely blind flight and landing of an aircraft in March 1933. His ILS is now operating at many airports, and wide adoption throughout the world is planned. Another development of world-wide importance in which he had a major role is the radiosonde, which automatically collects weather information from the upper atmosphere. This device was a vital element in weather forecasting during the past war.

Late in 1942 Mr. Diamond was asked to form a new division within the Bureau of Standards, primarily for research and development on electronic devices for Government and industry. It was this division that worked on the radio proximity fuze for bombs, rockets, and mortar shells. Other contributions of the division to the radio art include visual beacons for aircraft guidance, antenna systems, range-beacon course-alignment procedures, a simultaneous phone and range-beacon system, aircraft-engine ignition shielding, automatic weather stations, upper-air wind-velocity determination by radio, a method for measuring direction-finder polarization errors, and an electronic bomb director.

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JOURNAL
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VOL. 38 OCTOBER 15, 1948 No. 10

ARCHEOLOGY.—*Palachacolas Town, Hampton County, South Carolina.*[1]

JOSEPH R. CALDWELL, River Basin Surveys, Bureau of American Ethnology, Smithsonian Institution. (Communicated by FRANK H. H. ROBERTS, JR.)

The importance of the archeological site Palachacolas Town on the lower Savannah River lies in the certainty of its historical dating and ethnological identification. Pending the development of a general method of dating archeological materials in eastern North America,[2] the only absolute chronology available is for localities known to have been occupied by specific groups of Indians in historic times. Archeological materials and artifacts from sites which were not reoccupied or inhabited prior to the documented dating can be presumed to have been in use during the period of the recorded dates. Conversely, such artifacts can then help date other undocumented sites at which they may be found.

Palachacolas Town, later called Parachocolas Fort or simply Parachuckle, was situated on the right bank of the Savannah River about 50 miles from the mouth. The site had been occupied sometime during 1680–1716 A.D. by a band of Appalachicola Indians, who were Lower Creeks speaking the Hitchiti dialect.

The Creek Migration legend places these people in southwestern Georgia when they were first encountered by the invading Muscogee, and Swanton has pointed out that they later composed an important town in the Creek Confederacy[3]:

> . . . shown by the Creek name which it bears, Talwa lako, "Big Town," and from Bartram's statement that it was the leading White or Peace town . . . in Chiaha Square, September 18, 1768, a Lower Creek speaker says: There are four head men of us who have signed our names in the presence of the whole lower Creeks as you will see: Two of us out of Pallachicolas which is reckoned the head town of the upper and lower Creeks. . . .

The Appalachicola remained in southwest Georgia at least until 1680[4] but Milling has marshalled data to show that they arrived on the Savannah River no later than 1684.[5] Certain it is that these people were located on the Savannah River for some time prior to 1716 and abandoned the town in that year, after the Yamassee War. According to Swanton:

> . . . the Apalachicola, and part of the Yuchi and Shawnee, abandoned their settlements on the Savannah and moved over to the Chattahoochee. The Apalachicola chief at that time was named Cherokee Leechee (Cherokee killer). The date is fixed by a manuscript map preserved in South Carolina. They settled first at the junction of the Flint and Chattahoochee Rivers, at a place known long afterwards as Apalachicola Fort. Later they abandoned this site and went higher up; in fact, they probably moved several times.[6]

Evidence to substantiate a dating between 1680 and 1716 is found at the Palachacolas site itself, for the fragments of Indian clay pottery there closely resemble potsherd material from the historic (Hitchiti) Trading Post, at Ocmulgee near Macon, Ga., dated 1680–1718, and resemble sherds from the Kasita site, near Columbus, Ga., late seventeenth to early eighteenth centuries.[7]

[1] Received August 16, 1948. This paper is published by permission of the Secretary, Smithsonian Institution. The bulk of the material described is in the United States National Museum.

[2] See MARTIN, QUIMBY, and COLLIER, 1947, pp. 9–13, for a recent summary of methods of archeological dating. Also Kelly, 1939.

[3] SWANTON, 1922, p. 129.

[4] *Ibid.*, p. 130.

[5] MILLING, 1940, pp. 176–177.

[6] SWANTON, 1922, p. 131.

[7] KELLY, 1939, p. 332. See also Newsletter, Southeastern Archaeological Conference, pottery

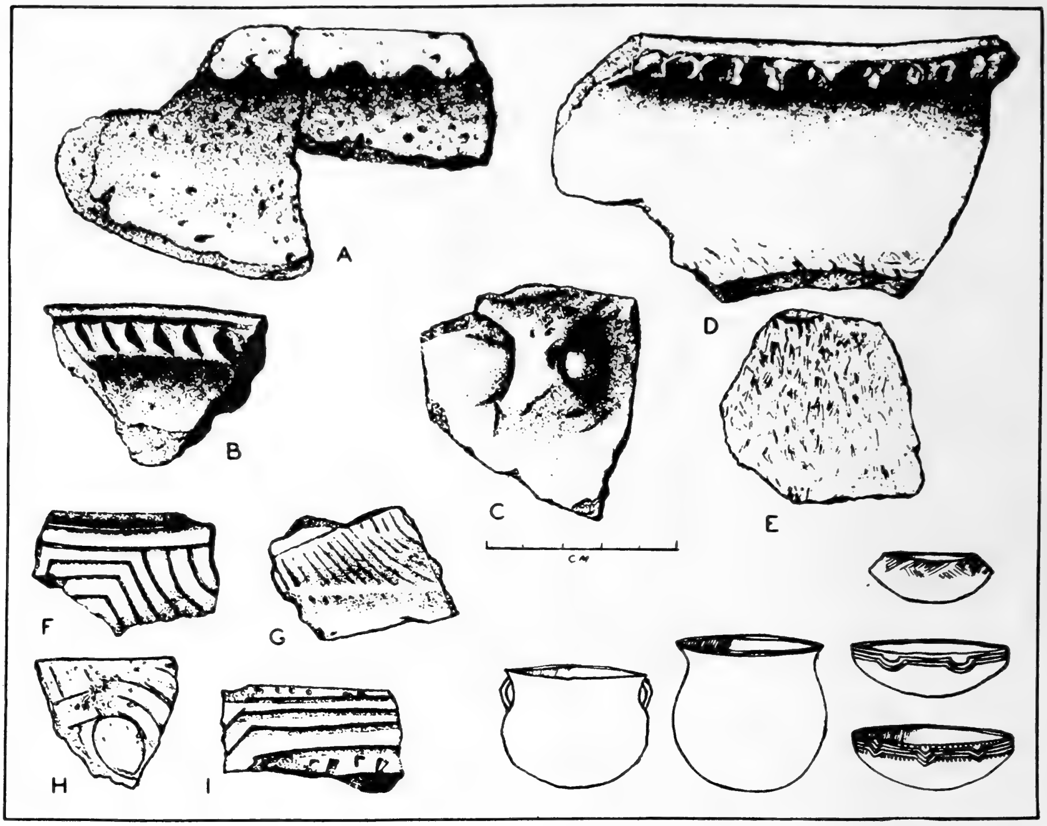

FIG. 1.—Historic Indian pottery from Palachacolas ca. 1680–1716 A.D.

In 1901 D. Roland Steiner sent two small pottery vessels and some glass beads from Palachacolas to the United States National Museum. We do not, unfortunately, know the circumstances under which this material was found. A much larger collection was received in 1943 through the courtesy of Marmaduke H. Floyd, of Savannah, Ga. A few potsherds were also obtained by the writer when he accompanied Mr. Floyd to the site in 1939.

POTTERY

The larger of the two pottery vessels found by Steiner is shown in Fig 2, A. Both have a similar form which is characteristic of the western Georgia type *Kasita Red Filmed.*[8] They are fired to a reddish color extending through the paste, and the smaller vessel appears as if it might have been painted. This specimen shows no tempering material, but grit particles are present in the larger. Both have their surfaces carelessly smoothed, but the coil fillets on the exterior of the one shown were left partly unobliterated, perhaps for the effect.

The sherds in Fig. 1 are all from the writer's collection, but the description here includes Floyd's ceramic material as well. Altogether there are seven sherds decorated by incising (B, F, G, H, I) conforming closely to the type *Ocmulgee Fields Incised.* Six are from shallow bowls, two with a carinated shoulder. The firing colors range from reddish buff to dark gray. The two dark gray sherds are burnished, and nearly all the rest are carefully smoothed on both surfaces. No tempering material can be seen, but some small lacunae are present.

The 16 plain sherds have the same paste features as those decorated by incising, but

types: *Ocmulgee Fields Incised, Kasita Red Filmed, Walnut Roughened.*

[8] See preceding footnote.

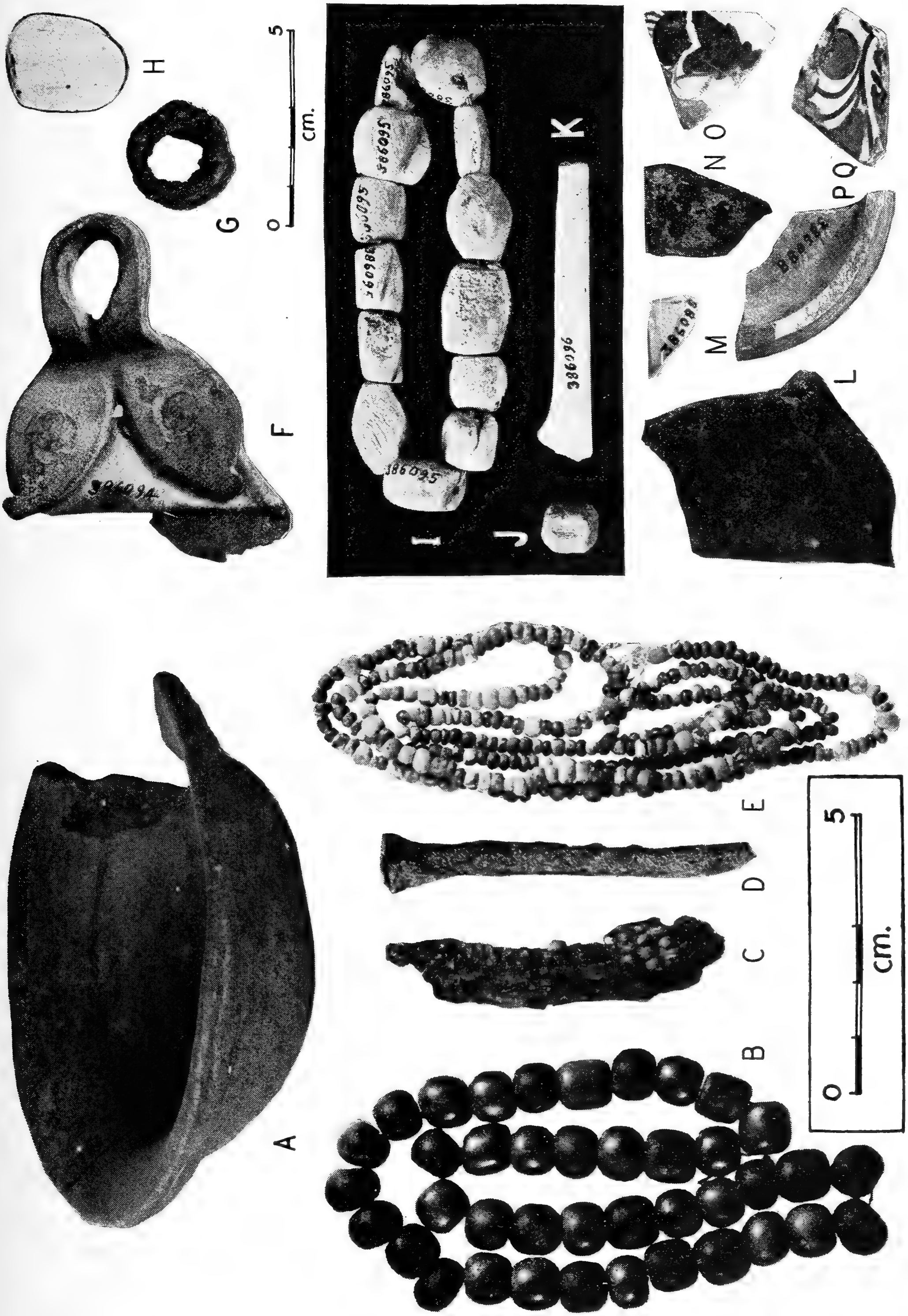

Fig. 2.—Historic artifacts from Palachacolas.

three of the four rimsherds in the sample are from flaring rim vessels, and the form of the other is uncertain. One has an indented rim band, and another has a handle suggesting Mississippian influence (Fig. 1, C). No historic plain type has yet been described from Ocmulgee or Kasita, but undecorated sherds are represented in the collections there.

Three sherds show a roughening of the exterior by the use of short incised or scratched lines (Fig. 1, D, E) and are evidently counterparts of the Ocmulgee type *Walnut Roughened.* They have the same paste characteristics as the sherds described above. One shows a pinched rim band.

There are six shell-tempered sherds. The specimen illustrated (Fig. 1, A) is from a flaring rim vessel with a thickened lip, notched at the lower edge. Four sherds are decorated with a carelessly applied cord-wrapped stick or paddle, the impressions somewhat smoothed over. Another is the rounded base of a vessel, again showing the use of cord.

There was one sherd of the type *Lamar Complicated Stamped*, a type slightly earlier than those we have been discussing.[9]

OTHER ARTIFACTS

The glass beads in Fig. 2, B, E, are a small portion of a number found by Floyd with a burial 18 inches deep in the exposed face of the bluff. Similar beads and other objects were sifted from sand at the foot of the bluff and were presumably from the same interment. There were two massive conch columella beads similar to the string shown in Fig. 2, I. The group of small red beads shown adhering to an iron fragment (C) was apparently from beadwork sewn to clothing. The wrought-iron nail (D) is one of two which, if actually associated with the burial, may indicate that it was originally in a wooden coffin.

With another burial 12 inches deep in the bluff Floyd found many glass beads, two massive columella beads, and three of the shell-tempered sherds mentioned earlier. Also present were a conch shell disc, Fig. 2, H, an iron ringlike object (G), and a part of a copper cauldron (F).

With a third burial which had fallen out of the bluff Floyd found glass beads similar to those shown, as well as the shell beads (I), pipestem (K), and lead bullet (J) illustrated in Fig. 2.

On the surface but near the bluff Floyd found, in addition to some of the Indian pottery described, crockery (L, P), chinaware, glass (M, N), and trade pipe fragments.

[9] Newsletter, Southeastern Archeological Conference, 1939, pottery type *Lamar Complicated Stamped.*

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ARCHEOLOGY.—*A seventeenth-century fireplace at Maspeth, Long Island.*[1]

RALPH S. SOLECKI, River Basin Surveys, Bureau of American Ethnology, Smithsonian Institution. (Communicated by FRANK H. H. ROBERTS, JR.)

In April 1935 an early colonial fireplace dating from circa 1650 was found by the writer and a companion, Stanley Wisniewski, in an open lot at Maspeth, Long Island. The material found in the fireplace links the historic with the prehistoric periods there.

Maspeth is an incorporated town situated within the limits of Greater New York City in the Borough of Queens. It is on a tributary of Newtown Creek, which is part of the boundary line between the Boroughs of Brooklyn and Queens, and opens at the East River opposite lower Manhattan. The tributary, Maspeth Creek, was called

[1] Received August 16, 1948.

"Mespat Kill" in the seventeenth century, and the land adjacent to it was called "English Kills" in recognition of the first English settlement made in this locale.

Newtown Creek today is one of New York City's most important unloading points for sea traffic in coal, oil, and lumber. Maspeth, now only half an hour from Times Square, was the backwoods and outlying settlement of New Netherlands 300 years ago.

Maspeth, the present name of the town, is derived from both the English and Dutch versions of Mespaetches or Maspechtes, which approaches the idiom of the aborigines. The names "Mespat" and "Mispat" appear in seventeenth century writings and maps, and in keeping with this practice we will use the name Mespat. Mispat appears on A. Van der Donck's map of 1656 (see Fig. 1), which apparently had been copied by later cartographers.

The Canarsee Indians, with whom the early settlers had many dealings, were a strong western Long Island tribe of the Metoac or Matouwac confederacy. They had one of their principal villages on Mespat Kill.

Aboriginal artifacts attesting to occupancy in pre-historic times were there prior to the development of Newtown Creek and environs. These artifacts were quite numerous, suggesting that a fairly large Indian village had been there (Bolton, 1922, pp.173–175). The situation was favorable enough, with creeks, hills, forests, and pleasant country. Game of all kinds was plentiful, according to early records.

The first settlement within the bounds of Newtown was made in 1642 by a Reverend Francis Doughty, a newcomer to New Netherlands from New England, where he had experienced difficulty with the founding fathers. He and his associates were granted settlement privileges at Mespat by William Kieft, the Director-General of New Netherland (Riker, 1852, pp. 17–19). Reverend Doughty and his flock had barely time to establish house, when the native Indians, instigated into war in 1643 with the colonists by the gross blunders of Kieft, attacked the settlements around New Netherland, including Mespat. Its inhabitants were forced to flee, and their homes and farms were devastated and ruined. Thus was broken up one of the budding English settlements on Long Island.

Director Kieft made overtures to the Indians and, with the help of several wiser men, placated them. The settlers returned to Mespat, but the settlement never recovered from the shock of warfare.

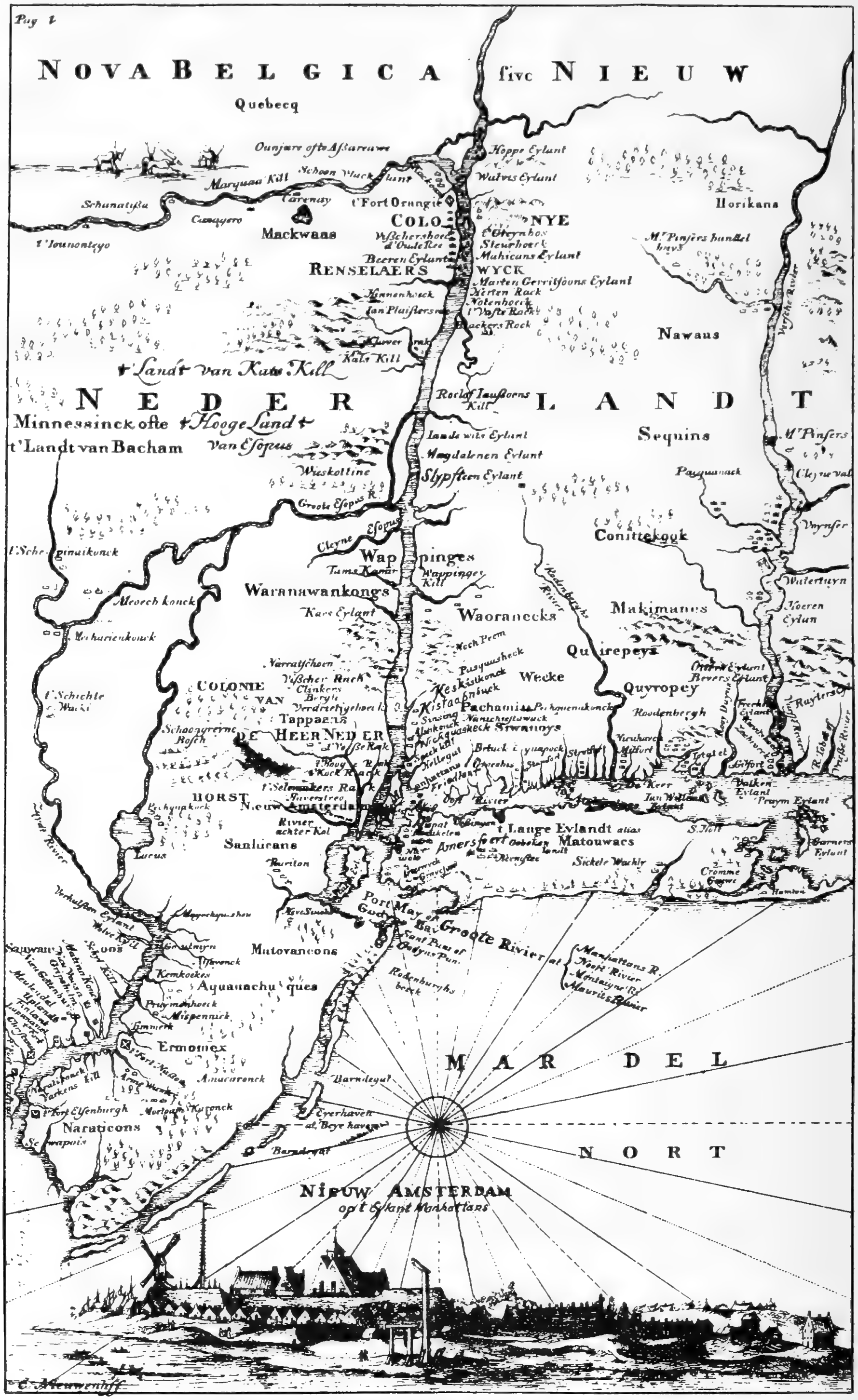
Mespat was seized with terror again in 1653, during the Dutch and English war (1652–1654), when the English settlers learned that the Dutch were negotiating with the Indians to destroy the English on Long Island. The Mespat settlers once again fled, this time to Stamford, Conn., a strong English settlement. The war ended, and the settlers dribbled back again. Another alarm was made in 1656, when this time the Dutch neighbors of the English at Mespat, in fear of retaliations from the Indians, banded together for safety. They concentrated themselves for mutual protection on Smith's Island at English Kills. This island appears on later maps as Furman's Island, or Maspeth Island (now a part of the mainland, and covered by an aluminum plant).

This new settlement was called Aernheim in honor of the leader's birthplace on the Rhine. The leader was Nicasius De Sille, one of the governor's council, who had obtained the patent to the island on March 27, 1656. By April the diligent villagers were mowing the meadows.

Brief excitement occurred when a small group of Raritan Indians killed a family at Mespat Kill in 1659.

Director Stuyvesant and his council terminated the existence of Aernheim on Smith's Island in 1661, because they feared that it might hinder the growth of Bushwick, which was planted in 1660 by the French and a few Dutch.

There were no further Indian troubles, and the Canarsees settled the last piece of their reservation to the English in 1666 for £66 and some change. A scattering of Indians remained, "some of whom had their wigwams at Mespat Kills" (Riker, 1852, p. 73) for several years later. Disease, wars, pestilences took their toll of the Indian population within the first 50 years of the



MAP OF NEW NETHERLANDS,
With a view of New Amsterdam, (now New-York,) A. D. 1656.
Copied for the N. Y. Hist. Soc. from the Map of A. Vander Donck.

Fig. 1.—Map of New Netherlands, A.D. 1656. From A. Van der Donck, *Description of New Netherlands.*

colonization of New Netherland, as it did everywhere on New England, and Indian survivors into the eighteenth century were few indeed.

THE FIREPLACE

The .site of the fireplace was located between what was formerly known as Shanty Man's Creek and Maspeth Creek, or Mespat Kill, on the road to old Aernheim. The present road is called Maspeth Avenue. The fireplace faced the northeast about 30 feet south of Maspeth Avenue in line with Milton Street. When found, the fireplace was covered (Fig. 2, F) except for a corner of yellow brick protruding from the slope, by an eroded sand bank 3 feet deep. The hearth and back and sides of the fireplace were uncovered easily in the sandy soil. It was $3\frac{1}{2}$ feet long and $1\frac{1}{2}$ feet high. A 6-inch layer of wood ashes and black earth was found at the top, lying over a carefully laid arrangement of yellow bricks on the left side of the hearth. Directly beneath them was a large flat oblong stone, weighing about 150 pounds. To the right of it, at the same level, were several smaller flagstones, obviously part of the hearth also. The bricks and paving stones were surrounded by ashes and charcoal. The majority of the specimens recovered were found in the ash bed above the floor of the fireplace.

In clearing around the outside on a level with the fireplace, we found the remains of what probably had been a shelter at the southwest side. To judge from the amount of ashes and charcoal present, this shelter had evidently burned down. Enough identifiable wood material remained to ascertain that pine was used in the structure. Unfortunately, more could not be determined about it, as the sand bank had been considerably eroded in this part of the area. An iron hammer resembling a cobbler's hammer with iron shanks at the handle end was found in association with the ashes.

Both native Indian and Colonial materials were found in the fireplace.

The Indian material consisted of 25 flakes and chips of red and black flint, and a broken reject artifact of dark flint.

Among the European material were 22 pieces of white kaolin pipestems, 7 complete pipe bowls of which three were marked with the initials PG on the heel, 1 fragmentary pipe bowl, 17 lead buckshot balls about .26 caliber, 8 balls about .38 caliber, 2 lead balls about .70 caliber, a dark gunflint, 6 small pieces of blue china plate, 39 hand-wrought iron nails, and 26 pieces of clay bricks, mentioned above. These were crudely fashioned, not all of the same dimensions and somewhat smaller than modern building bricks. There were five whole bricks in the collection. There were also found two pieces of reddish-clay pipe bowls, which seem to have been fashioned in crude imitation of the European kaolin pipes.

Leisure time at the hearth was not only spent in "drinking smoke," as the custom was known in the early seventeenth century but apparently also in more artistic pursuits. This evidence we find in the form of a flat bit of diamond-shaped bone, three quarters of an inch in length, carefully cut to shape and carved on its face with a sharp tool (Fig. 2, D).

The dating of this fireplace may be bracketed by the finds through comparing the specimens with similar objects of known date.

It is a matter of history that the Dutch, during the colonization of New Netherland, imported numerous lots of bricks from the Continent. These bricks served as ballast in the holds of their ships, which went back laden with products of the New World, especially furs. The white kaolin pipes, however, are a more sensitive time indicator, because clay pipes are not so indestructible as the bricks. In addition, it is known and recorded that several styles of pipes were in vogue among the pipemakers since the first "Elizabethan" or "fairy" pipes appeared in the latter part of the sixteenth century, with the introduction of the smoking habit by Ralph Lane in 1586. Tobacco at this early date was quite an expensive luxury, and pipe bowls were thus necessarily small. The pipe bowl illustrated (Fig. 2, A) is one of the typical bowls found in the fireplace. The bowl is barrel-shaped, slanting upward obliquely from the stem. It has a milled edge around the rim, as if made with a small coin. The bottom of the bowl terminates in

a flat "heel," which was typical of the seventeenth-century pipes and was supposed to hold the pipe in an upright positon when placed on a flat surface. The fact that this heel changed its shape into a pointed spur a century later may belie the efficacy of the heel for supporting the pipe. Of particular interest for the antiquarian are the pipemakers' trade marks, generally found on the heel (Fig. 2, C). These were usually the pipemaker's initials impressed in relief within a circle. A search through the lists of

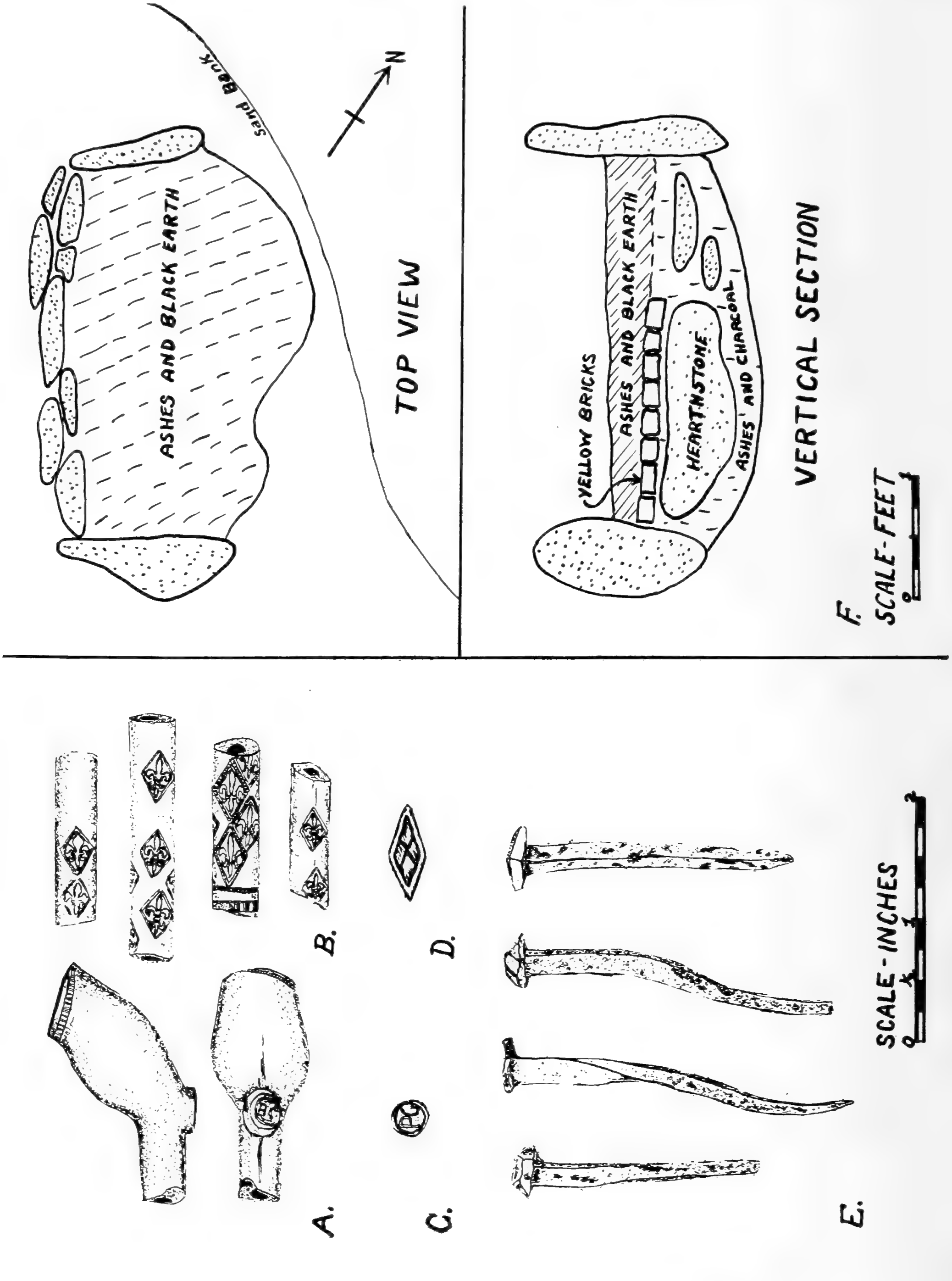


FIG. 2.—The Maspeth fireplace and artifacts: A, B, European pipe bowl and stems. C, Heel of pipe bowl with maker's impression "PG." D, Worked bit of bone. E, Wrought-iron nails. F, Top view and vertical section of the fireplace.

pipemakers of Hull and Bristol, England, will identify many of the pipes brought to America. A good many of these were used in the Indian trade. The Dutch had lively pipe manufactories also, which they seem to have copied from the English. They also kept a brisk business in pipes overseas. We do not have any data on the pipemaker "PG," whose stamp was found on three of the pipebowl heels, but from comparison of the type bowl with pipes of known date we can place the date of manufacture about the middle of the seventeenth century. The fleur-de-lis design found on eight of the pipestem pieces (Fig. 2, B) is also a good time marker, as it was popularly impressed on stems about this period. The holes in the pipestems were large, and the stems were about 8 inches long, tapering toward the mouthpiece. The so-called "church-warden" pipes, with the long stems for the cool smoke, did not make their appearance until considerably later in pipemaking history.

CONCLUSION

We may well speculate whether this fireplace had been part of Reverend Doughty's settlement and had been destroyed by the Indians during their depredations here, as the material evidence seems to be coeval. This is important to the historian, but of interest and significance to the archeologist is the presence of the flint chips. These point to associations of the whites with the Indians. We cannot say definitely that the fireplace was not of Indian construction, but from what we know of early Colonial and Indian fireplaces, the possibilities are greater that this fireplace had been made by the settlers. How to explain the presence of the flint chips other than that they demonstrate the contact period between the whites and Indians is a moot point. This borderline phase of our early history had not received the research and attention it justly deserves by archeologists.

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CHEMISTRY.—*A study of dithizone as a reagent for indium.*[1]

Irving May[2] and James I. Hoffman, Lecturer in Chemistry at The George Washington University.

Indium is generally found in nature as a trace constituent of zinc ores and is obtained commercially from the residues of zinc distillations. Sensitive methods for determining indium in the presence of zinc are therefore of importance in the analysis of indium-bearing materials.

The spectrographic method is the most common one in use for determining small amounts of indium, and only a few colorimetric methods are described.

Therald Moeller (*1*) developed a colorimetric procedure for estimating small amounts of indium based upon a chloroform extraction of the indium derivative of 8-hydroxyquinoline. This method has the disadvantages of being somewhat insensitive and of being subject to numerous interferences. Nevertheless, it is capable of effecting a number of important separations and is useful for isolating indium from many metals.

The reaction of dithizone with indium was first reported by Hellmut Fischer in a brief statement which is given in translation:

> Indium is one of the few trivalent cations which react with dithizone. To be sure, solutions of trivalent indium salts, upon shaking with a solution of dithizone dissolved in carbon tetrachloride, give a red coloration in the carbon tetrachloride

[1] From a thesis submitted by Irving May to the faculty of The George Washington University in partial fulfillment of the requirements for the degree of master of science, February 1948. Received August 13, 1948.

[2] Present address, U. S. Geological Survey, Washington 25, D. C.

phase only when a very definite and narrow pH range (between 5 and 6) is maintained. The reaction also proceeds in the presence of cyanide ion, if the solution is previously brought to the above mentioned pH range. The dithizone complex is decomposed merely by washing with a dilute ammonia solution (1 part of ammonia to 1000 parts of distilled water). Further investigation of the composition of the complex and its analytical application have not yet been carried out (*2*).

Subsequent investigators of the dithizone reagent have not published any additional material on its reaction with indium. Wichmann (*3*), in a comprehensive review of the dithizone system, stated that indium, as well as ferrous iron, manganese, and trivalent thallium "react with dithizone under certain conditions, but their dithizonates are of limited stability and probably of no analytical significance. The field for further investigation is still wide open."

It was thought that a more thorough investigation of the reaction of indium with dithizone than had been made by Fischer might lead to a useful method for the determination of indium. A general study was therefore made of the reaction of indium with dithizone. Tentative procedures were then developed for separating indium from other metals and its determination with dithizone.

The authors are aware of the fact that further work on this subject would be highly desirable. Unfortunately, it is unlikely that they will be in a position to pursue this study any further, but enough new information concerning the reaction of indium with dithizone has been developed to make its publication of value to others interested in this subject. It is believed that the tentative methods developed will be useful for determining indium in many types of materials.

THE REACTION OF INDIUM WITH DITHIZONE IN CARBON TETRACHLORIDE SOLUTION

The optimum conditions for the extraction of indium by carbon tetrachloride solutions of dithizone were determined. The absorption characteristics and the stability of indium dithizonate were next investigated. Similar studies were also made employing chloroform as the solvent.

The color of indium dithizonate in carbon tetrachloride and in chloroform solutions is rose-red. It was observed that carbon tetrachloride solutions of indium dithizonate underwent a visible reddening in color on standing exposed to afternoon room light.

The absorption curve of indium dithizonate in carbon tetrachloride medium was measured. A solution for this purpose was prepared by shaking a carbon tetrachloride solution of dithizone (0.001 percent wt/vol, that is, carbon tetrachloride containing 10 mg. of dithizone in a liter) with an excess of an indium nitrate solution at pH 5.8, avoiding any exposure to light. Part of the dithizone layer was drawn off and the absorption curve was measured. The absorption curve was also determined on another portion of the sample which had been permitted to stand for 22 hours in the absence of light. These curves are shown in Fig. 1 as is the curve of the 0.001 percent dithizone solution.

The curve for the dithizone solution agrees closely with similar ones previously published (*4*, *5*). The absorption curves for indium dithizonate are very similar to those for other metal dithizonates. The maximum absorption of indium dithizonate is at 510mμ, at which wavelength dithizone has a minimum absorption.

Comparison of the two indium dithizonate curves reveals that, on standing, there is a small but definite increase in optical density in the regions of 510 and 600 mμ. The aging effect over a short period of time, such as an hour or less, is not likely to result in serious errors in quantitative work.

Indium dithizonate solutions in carbon tetrachloride were found to be sensitive to light. A portion of indium dithizonate solution, prepared as described above, was exexposed to afternoon room light for $1\frac{1}{2}$ hours. The optical density at 510 mμ changed from 0.688 to 0.713, whereas an unexposed portion of the sample changed to 0.693.

Exposure to the intense light of a 750 W projection bulb resulted in appreciable decomposition of the dithizonate. The light was focused on the sample, and heat was removed by heat-absorbing filters. Samples were exposed for 5 and for 15 minutes. The

samples looked green when first removed from the light, and some recovery of color was apparent in the short interval that elapsed before the measurements could be made. The optical density changed from an initial value of 0.688 to 0.664 for a 5-minute exposure and to 0.465 for a 15-minute exposure. After standing in the instrument for 10 minutes, the density of the 15-minute sample increased to 0.512 and then remained unchanged. This behavior is similar to that of mercury dithizonate.

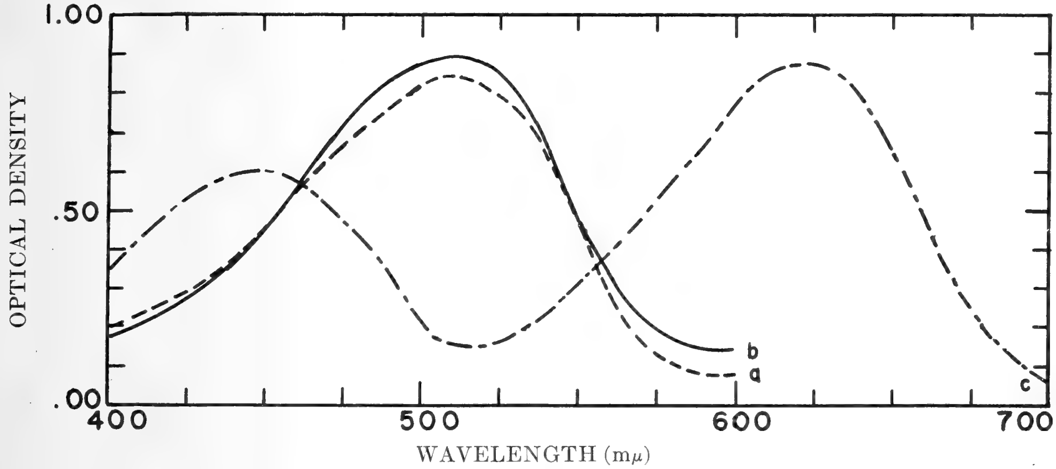

Fig. 1.—Absorption curve of indium dithizonate in carbon tetrachloride solution: *a*, Absorption curve of freshly prepared indium dithizonate solution; *b*, Absorption curve of indium dithizonate solution after standing for 22 hours; *c*, Absorption curve of the dithizone reagent, in carbon tetrachloride. (The same general form of curve is obtained with chloroform as the solvent.)

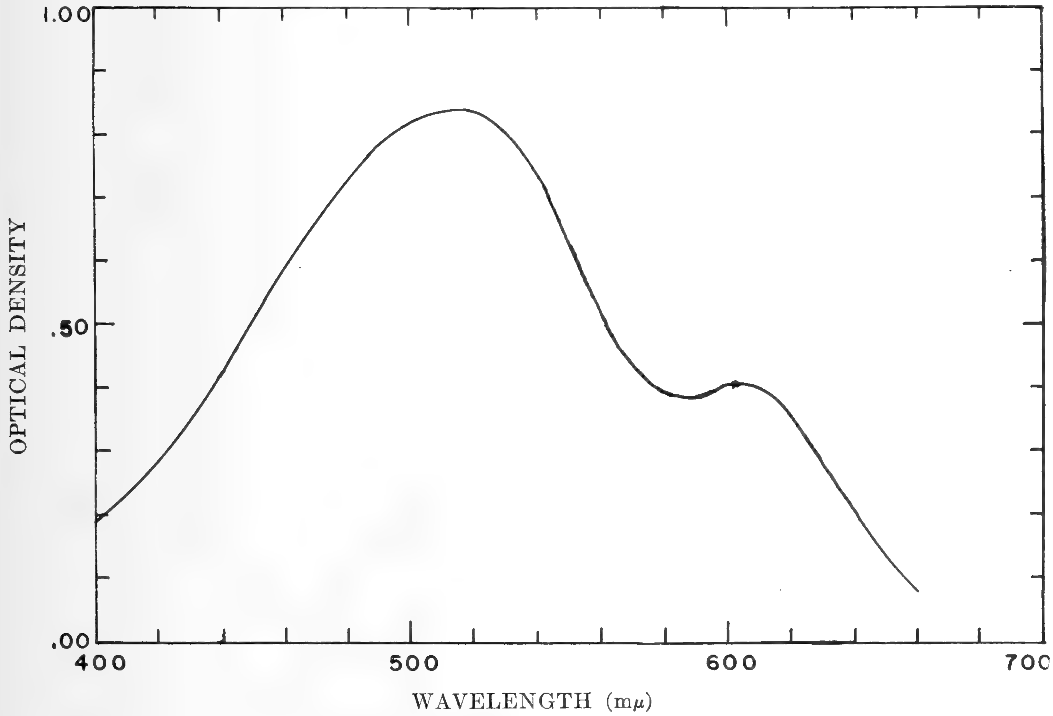

Fig. 2.—Absorption curve of indium dithizonate in chloroform solution.

The optimum pH range for the extraction of indium by carbon tetrachloride solutions of dithizone was found to be between 5.2 and 6.3, agreeing with the values given by Fischer (pH 5–6). Some extraction occurs on either side of this range. Thus, at a pH of 4.8 or 6.7, about 60 percent as much indium could be extracted by a given volume of dithizone, compared with what would extract at the optimum pH. There was some evidence that small amounts of indium would extract at as low a pH as 2 and possibly even at as high a pH as 8.

Indium dithizonate in carbon tetrachloride solution was found to obey Beer's Law. Solutions containing 0 to 14 micrograms of indium at a pH of 5.5 were extracted with 15-ml portions of a carbon tetrachloride solution of dithizone (16 mg of dithizone per liter of carbon tetrachloride). A plot of the transmittancies of the dithizone layers at 490 mμ against concentration of indium showed that the solutions adhered to Beer's Law.

It was found that the presence of citrates or tartrates prevented the extraction of indium by dithizone, but extraction did proceed readily in the presence of hydroxylamine-hydrochloride.

The conditions which were established for the optimum extraction of indium by carbon tetrachloride solutions of dithizone are the very ones which favor the extraction of zinc. Attempts to find a complexing reagent which would prevent extraction of zinc and yet allow indium to be extracted by the dithizone solution were fruitless. A method, however, was desired for indium in the presence of zinc. Since there was nothing in the literature on the extraction of indium with chloroform solutions of dithizone, it was decided to investigate the extraction, employing chloroform as the solvent.

THE REACTION OF INDIUM WITH DITHIZONE IN CHLOROFORM SOLUTION

Investigation of the reaction of indium with chloroform solutions of dithizone revealed that indium formed a dithizonate in the presence of moderate concentrations of cyanide, at a higher alkalinity than in the case of the carbon tetrachloride medium. Maximum extraction of indium occurred in the pH range 8.3 to 9.6. Extraction of indium was very incomplete at pH below 7 and above 10.

The absorption curve of a chloroform solution of indium dithizonate was measured (Fig. 2). The dithizonate was prepared by extracting a solution of indium nitrate containing potassium cyanide (pH = 9.1) with chloroform containing 10 mg of dithizone in a liter. The absorption peak of the dithizonate in chloroform is at 510–520mμ. The hump in the curve in the region of 600 mμ is probably caused by the presence of unreacted dithizone.

A study was made of the stability of indium dithizonate in chloroform solution. On standing in the absence of light, there was a slow decrease in optical density at 510mμ, accompanied by a slight increase in density at 620mμ. At 510mμ the density dropped from an initial value of 0.845 to 0.822 after a lapse of 37 minutes, and to 0.798 after 22 hours.

Unlike carbon-tetrachloride solutions of indium dithizonate, chloroform solutions of the dithizonate were found to be fairly stable to light. Exposure to room light for 45 minutes resulted in no greater change in density at 510 mμ than in the case of the sample standing for a similar period protected from light. Exposure to intense light resulted in a change in density at 510 mμ from an initial value of 0.839 to 0.862 after a 5-minute exposure, and from 0.820 to 0.840 after a 15-minute exposure.

CUPFERRON AS AN AID TO THE EXTRACTION OF INDIUM WITH DITHIZONE

It was discovered that if cupferron is present and dithizone absent in aqueous cyanide solutions of indium, lead, or bismuth, all these metals could be readily extracted by chloroform at pH 8.5 The resulting chloroform solutions are colorless. It was then observed that if dithizone solutions were added to the chloroform-cupferron extracts, the corresponding dithizonate colors were obtained. The dithizonates are therefore stronger complexes than the cupferrates. As a result of a number of experiments, the following conclusions were reached concerning the extraction of indium

from solutions at a pH of 8.5 containing cyanide:

(1) In the presence of cupferron, but in the absence of citrate, indium is extracted by chloroform even if no dithizone is present.

(2) In the presence of both citrate and cupferron, the extraction is sufficiently retarded to require dithizone in the chloroform for efficient extraction of indium.

(3) Indium is extracted more readily with chloroform solutions of dithizone in the presence of cupferron and moderate concentrations of citrate than when both are absent.

When extractions are made from alkaline solutions with dithizone, it is generally advantageous to have citrates (or tartrates) present to avoid the precipitation of a large number of metals. The use of cupferron enables one to overcome the very pronounced retarding effect of citrates on the extraction of indium by dithizone.

SEPARATION OF INDIUM FROM ZINC AND OTHER METALS

The conditions established above for the extraction of indium by chloroform solutions of dithizone are essentially those generally employed for the extraction of lead. Bismuth, bivalent tin, and univalent thallium also form dithizonates under these conditions. Zinc, in moderate concentrations, is not extracted with this group.

It was determined that concentrations of cyanide greater than 0.3 g of KCN in 60 ml of solution at a pH of 8.5 hinder the extraction of indium by chloroform solutions of dithizone. It was also found that at this pH and in the presence of 0.3 g of KCN in 60 ml of solution, up to 10 mg of zinc may be present without any zinc being extracted by chloroform solutions containing 10 mg of dithizone in a liter.

Moeller *(1)* found that on extraction of indium with chloroform solutions of 8-hydroxyquinoline (oxine) at a pH range of 3.2 to 4.5 the interfering ions were aluminum, gallium, thallic, stannous, bismuth, cupric, ferrous, nickel, and cobalt. He reported that the ions not extracted under these conditions were magnesium, calcium, strontium, zinc, cadmium, mercuric, stannic, lead, manganous, chromic, and silver.

It can be seen that, with the exception of bismuth, extraction with oxine will separate indium from the metals which otherwise would interfere with the extraction of indium by dithizone. A procedure published by Hubbard *(6)* for the separation of bismuth from lead by extracting bismuth with dithizone from a solution at a pH of 3 would also serve to separate bismuth from indium.

On the basis of the foregoing considerations, tentative procedures for determining indium were evolved. The general plan was to first extract indium at a pH of 4 with a chloroform solution of oxine, free indium from the oxine complex, and then determine indium by extraction with a chloroform solution of dithizone.

PROCEDURES FOR THE DETERMINATION OF INDIUM

Detailed instructions for the preparation and purification of most of the following reagents are to be found in papers by Clifford and Wichmann *(4)*, and Bambach and Burkey *(7)*.

Water.—Double-distilled in an all-Pyrex still, or otherwise prepared so that it yields a satisfactory blank.

Nitric acid, conc.—Reagent nitric acid distilled in a Pyrex still.

Nitric acid, 1:99.—Ten ml of conc nitric acid made up to a liter with water.

Sulphuric acid, conc.—Select a bottle having a low blank value for lead and indium.

Perchloric acid, 60 percent.

Potassium cyanide, 10 percent.—Potassium cyanide frequently has a high metal content and may require purification.

Ammonium hydroxide, conc. (sp. gr. 0.9).—May be purified by distilling reagent ammonium hydroxide into double-distilled water.

Ammonia-cyanide mixture.—Two hundred ml of a 10-percent solution of KCN and 150 ml of concentrated ammonium hydroxide made up to 1,000 ml.

Chloroform.—U.S.P. or C.P. grades are generally satisfactory.

Dithizone solution. 0.001 percent.—Ten mg of dithizone dissolved in 1,000 ml of chloroform.

8-Hydroxyquinoline. 0.02 M.—Dissolve 1.5 g of reagent in 500 ml of chloroform.

Buffer. pH 4.—Dilute 115 ml of acetic acid

with about 500 ml of water, titrate with ammonium hydroxide to a pH of 4.0, and dilute to 2 liters with water.

Cupferron, 1 percent.—Dissolve 1 g of cupferron in 100 ml of water. A clear colorless solution should be obtained with a good grade of cupferron. Prepare *immediately before* use.

Sodium citrate, 20 percent.—Two hundred grams of the dihydrate in a liter of water.

M-Cresol purple indicator, 0.1 percent.

Methyl orange indicator, 0.1 percent.

DOUBLE EXTRACTION PROCEDURE WITH OXINE SEPARATION

The following procedure permits the presence of more than 10 mg of zinc. Lead, thallium, and tin are separated from indium and do not interfere. The presence of large amounts of tin and aluminum may give low results.

1. Dissolve the sample in nitric acid and evaporate. If tin is present, dissolve in hydrochloric acid, add bromine, and evaporate to dryness.

2. Dissolve the residue in a few drops of nitric acid (hydrochloric, if used in no. 1) add 0.5 ml of sodium citrate solution and 10 ml of water. (If thallium is present and the treatment of the sample has resulted in its oxidation, add 1 ml of 20-percent hydroxylamine-hydrochloride.)

3. Add 2 drops of methyl orange indicator and adjust to orange color (pH 4) with 1:4 ammonium hydroxide.

4. Add 25 ml of the buffer solution and transfer the sample to a separatory funnel.

5. Extract with four 5-ml portions of a 0.02-M chloroform solution of oxine.

6. Wash the oxine extracts with 25 ml of the buffer solution.

7. Drain the oxine extracts into a 100-ml Kjeldahl flask, wash the buffer solution with a 5-ml portion of the oxine solution, and add the oxine wash to the flask.

8. Add 1 ml of sulphuric acid and heat until the chloroform is volatilized. Destroy organic matter by adding 1 ml of nitric acid and heating gently until the reaction subsides. Add 1 ml of perchloric acid, heating gently at first and then vigorously until fumes of sulphuric acid are evolved.

9. Add 25 ml of water and 1 ml of 20-percent sodium citrate solution. If iron is present, add 1 ml of 20 percent hydroxylamine-hydrochloride. Heat the solution and boil gently for a few minutes.

10. Cool and add 2 drops of m-cresol purple indicator and then ammonium hydroxide until the indicator turns orange. Add 3 ml of 10-percent potassium-cyanide solution and then add ammonium hydroxide until a purple color is obtained.

11. Wash the sample into a separatory funnel and add 5 ml of a 1-percent cupferron solution.

12. Extract with 5-ml portions of 0.001-percent chloroform solution of dithizone until the dithizone no longer changes color.

13. Add 50 ml of 1:99 nitric acid to the dithizone extracts and shake for 1 minute.

14. Discard the dithizone layer, wash the nitric acid extract with 5 ml of chloroform, and then remove the chloroform completely.

15. Add 5 ml of the ammonia-cyanide mixture to the nitric acid extract, or to an aliquot of it made up to 50 ml with 1:99 nitric acid.

16. Add 15.0 ml of a standardized 0.001-percent dithizone solution and shake for 1 minute.

17. Read the dithizone layer in a spectrophotometer at 510mμ.

The dithizone solution is standardized by taking solutions containing 0 to 15 micrograms of indium and 1 ml of sulfuric acid through the procedure, beginning at step no. 9. A blank determination should be run through the entire procedure.

If bismuth is to be separated, the above procedure should be followed through step no. 14. Then adjust the pH to 3.0 by adding dilute ammonium hydroxide, using m-cresol purple indicator. Extract the bismuth with dithizone (the extraction is slow). Wash the aqueous layer with chloroform. Add the proper volumes of ammonium hydroxide and potassium cyanide solutions to bring conditions to step no. 16 and continue with steps nos. 16–17.

SINGLE EXTRACTION PROCEDURES

In many cases it would be quite possible to use a simpler procedure than the one outlined above. Thus, the following modifications could be made in a limit test for indium in zinc samples:

A dilute nitric-acid solution of the sample is adjusted with ammonium hydroxide (m-cresol purple) to an orange color. Three ml of 10-percent potassium-cyanide solution are added, and the adjustment of pH is continued until a purple color is obtained. The sample is extracted for 3 minutes with 15.0 ml of 0.001 -percent dithizone solution. The dithizone extract is then compared with indium standards, 0 to 15 micrograms of indium, which have been taken through the same procedure. This comparison may be made visually, or in a spectrophotometer at 510 mμ. Lead, bismuth, and thallium, if present, would be read as indium. High concentrations of tin, iron, and aluminum would probably cause low results. A variaation of this simplified procedure would be the addition of sodium citrate before neutralization, and cupferron before extraction.

Another variation in the procedure may be employed where the greatest accuracy and sensitivity are not necessary. The procedure outlined above is followed through step no. 11. Then the sample, or a suitable aliquot thereof, is extracted with 15.0 ml of dithizone-chloroform solution, and the transmittancy is read at 510 mμ. Standards, containing 1 ml of sulphuric acid, should be run beginning with step no. 9.

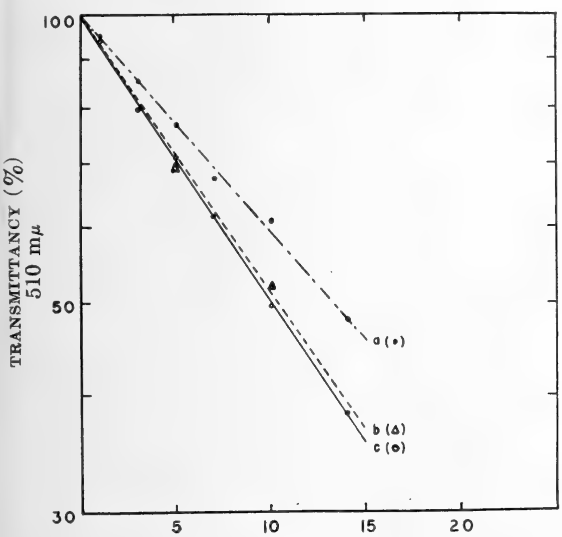

Fig. 3.—Indium dithizonate standards:
a, Single extraction procedure. Extraction in presence of sulphate, citrate, cyanide, and cupferfon;
b, Double extraction procedure;
c, Single extraction procedure. Extraction in the presence of citrate, cyanide, and cupferron (sulphate absent).

Table 1

Foreign metal initially present		Indium added	Indium found
Metal	Amount		
		micrograms	micrograms
—	—	1.0	1.2
—	—	3.0	3.0
—	—	5.0	5.2
—	—	9.0	8.7
—	—	10.0	9.2
—	—	14.0	13.1
Cu	10 mg	10.0	10.5
Pb	10	10.0	9.3
Fe	0.5	10.0	10.2
Ni	5	10.0	9.3
Co	5	10.0	9.0
Zn	10	10.0	9.0
Ga	5	10.0	11.5
Sn	10	10.0	5.0
Al	5	10.0	5.2
Al	10	10.0	5.3
Mn	5	10.0	8.4
Cd	5	10.0	8.4
Tl	5	10.0	8.1

RECOVERY OF KNOWN AMOUNTS OF INDIUM

Standardization of the same batch of dithizone solution by three of the above-mentioned procedures is shown in Fig. 3. Comparison of curves *a* and *c* indicates that there is a loss of sensitivity when the extraction is performed in the presence of high concentrations of ammonium sulphate.

The results for the recovery of known amounts of indium obtained with the procedure employing an oxine separation followed by a single extraction of indium are given in Table 1.

It will be observed that poor recoveries of indium were obtained in the presence of high concentrations of tin and aluminum. Samples containing much tin could probably best be handled by completely volatilizing the tin as stannic bromide from perchloric acid solution by the procedure of Wichmann and Clifford (*8*).

SUMMARY

The extraction of indium by carbon tetrachloride and chloroform solutions of dithiz-

one has been studied. Indium was found to be extracted with chloroform solutions of dithizone under the same conditions as the lead, tin, thallium, and bismuth group. Tentative procedures have been presented for the separation of indium from various metals and its determination by dithizone methods.

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PLANT PATHOLOGY.—Bacillus megaterium *de Bary from the interior of healthy potato tubers.*[1]

Benjamin Franklin Lutman and Harry E. Wheeler, Department of Botany and Plant Pathology, Louisiana State University. (Communicated by Nathan R. Smith.)

For several years the writers have been attempting to grow microorganisms from the filamentous plant intercellular inclusions which had been described by Lutman (*6, 7*). Various methods were used to induce them to leave their intercellular habitat and grow in another medium, but without success. Although a few actinomycetes were occasionally obtained, no assurance could be given that they were not accidentally introduced in the transfer of material from tubers to medium.

The technique that was used in the following work was neither new nor complicated. Burbank Russet tubers, grown in Idaho, were used for much of this work because they were available in the market and their long shape made them easy to break. At the time most of these trials were made these mature tubers showed sprouts, indicating that the rest period had been passed.

Clean, selected tubers were disinfected for 2 hours in 0.5 percent formaldehyde solution. They were dried and then cut on one side so that they could be broken readily. Disks of tuber tissue were removed with a sterile cork borer and a scalpel. Usually three or four of these circular disks (1 cm across and 1–2 mm thick) were taken from the broken surfaces and removed to bottles of sterile water. After washing they were placed in a small, sterile porcelain mortar, ground to a fine paste, and transferred to another similar flask of sterile water. The material from these flasks was plated out on nutrient agar to which had been added 2 percent dextrose and 1 percent yeast extract.

The broken tubers were placed between layers of sterile filter paper in a glass dish for five or six days, and then they were again used for samples. In this time the cut surfaces had developed a new cork layer from a cork cambium. The walls of the new cork cambium were filled with strands of hyphae, indicating that the microorganism had renewed its activity after being dormant in the tuber. The broken surfaces were washed off in 95 percent alcohol and the adhering alcohol burned off. Tissue disks, removed as just described, were broken up in the mortar to a fine paste and diluted 1 to 10,000 before plating.

The number of organisms obtained in the 3 operations varied widely with the tubers used. In one set of trials were 100 colonies per disk from the wash water, 700 colonies after the disk had been broken into fragments, and 33,000 from the disks taken from the regenerated skin. In another trial the numbers were 300 from a washed disk, 1,200 from a ground-up one, and 48,000 from a disk from a regenerated skin layer.

[1] Received August 5, 1948.

The organisms obtained, however, were not actinomycetes, but a large, curved-rod bacillus which was easily identified as the highly pleomorphic de Bary organism, *Bacillus megaterium.*[2] Occasionally, colonies of other organisms appeared on the plates, but the predominant form was always this bacillus.

For a long time these organisms were regarded as intruders from the soil and were disregarded. But, since they were so frequent, even with all precautions taken against the introduction of soil bacteria, a more careful examination was made of the colonies and of the individuals composing them. For this purpose the colonies that resulted from plating out the tissues were used, their age usually being 24 to 72 hours.

Colony margin.—The filaments protruding from the margins of the colony frequently showed branching, although in some colonies the individuals were pressed together in parallel, concentric circles to form a smooth margin. The most striking variation from an ordinary bacterial colony was the long filaments that would break away from the colony margin to push out across the agar to some distance, where they would bud off a new, small daughter colony. Rettger and Gillespie (*9*) gave the appropriate name of "runners" to these long nonseptate and unfragmented hyphae and offered the explanation that their appearance was stimulated by a lack of oxygen in the parent colony.

Reproduction and unusual individuals.—The unusually large size of the organisms (1.2 to 1.7 microns in width and averaging 5 to 10 microns in length) gave an opportunity to observe the details of cell reproduction by budding. Smith, Gordon, and Clark (*10*) in their monograph of this group state that *B. megaterium* produces apical and side buds. This description of bud formation is shorter and clearer than that of de Bary (*2*) who goes into considerable detail in the growth of the buds and the curvature of the rods: "The rods divide by the formation of a transverse septum into two members, the transverse septa are extremely delicate when young. When two sister rods begin to separate transversely from one another, the curvature usually becomes more pronounced at the extremities where division takes place, and the ends of the rods become slightly oblique to one another and overlap each other a little, or one thrusts itself laterally past the other, like the short commencement of a so-called false branch in Syctonema and similar genera of the Nostcaceae." His figure, however, shows clearly side buds, although all buds originate near cell apices.

Budding would automatically deny the name of the group to which it had been assigned, the Schizomycetes (fission-fungi). As a result of the buds and continued apical growth, true branching is common in the cells of these colonies derived directly from potato tissue. On replating these colonies, however, the branches or buds were shorter, so that the curved rods usually considered typical for this species now predominated. Rettger and Gillespie (*9*) had noted that these so-called "abnormalities" were always more frequent near the colony margins where oxygen supply was more abundant. At the centers and in the depths of the colonies fragmentation into short curved rods introduced the "normal," i.e., the laboratory type, of the species. The long filaments, branching cells, etc. were not permanent, but would resume their normal form if returned to any of the standard media (*4*).

Spore formation and sheath.—Occasional long filaments may be seen in the colonies. They fragment by the introduction of biconvex vacuoles. The protoplasm retreats and the empty space enlarges and becomes biconcave. This fragmentation is marked near the end of a filament where the protoplasm frequently fragments in a short branch into three or four capsule-shaped spores enclosed in a clear sheath. These short rows of spores are usually curved as are those of the actinomycetes. These spores would be the conidia of these latter filamentous species and are to be distinguished from the endospores described in some strains of *B. megaterium* but which are absent in other strains, and may be lost occasionally from those having them (*5*).

[2] The authors will use the original de Bary spelling.

No endospores were observed on these strains when grown on dextrose agar.[3]

Rettger and Gillespie (*8*) noted so-called "empty sausage" skins (sheaths empty of protoplasm) but did not consider them of special importance, presenting their observations "as a matter of general interest, rather than as evidence of the occurrence of a highly specialized cell membrane or envelope in bacteria." They did not call attention to the fact that the actinomycetes have such an envelope or sheath, even if other microorganisms do not. This envelope or skin has been investigated by a number of electron microscope workers. Dubin and Sharp (*3*) arrived at the conclusion that "electron micrographs indicate plainly the presence of two structures constituting the bacterial cell, an inner dense substance and outer less dense substance. The outer substance of the bacterial cell is invisible in light micrographs." To the latter statement, the authors would in part disagree, since this sheath may often be seen between the fragments of protoplasm, especially after dense staining.

Germination of the intercellular strands.—The best proof of the origin of the colonies from the intercellular filaments would be to grow them from between the cells out into a culture medium. In order to demonstrate this point a somewhat different technique was used.

Some of the ground-up regenerated cork layer in a 100-cc water suspension was pipetted on large (24 by 50 mm) cover glasses, where it was allowed to air dry. A thin layer of the nutrient agar used in the plates was then spread over these dried tissue fragments. After it had hardened the cover glass was inverted over a slide, the ends of the cover glass being suspended by fine glass rods. The slide was then placed in a damp chamber.

In a warm room germination would begin in about two to three hours. Probably more than 90 percent of the germinations would have no connection with bits of tissue. They seemed to originate in fragments of mycelium loosened from their intercellular attachments by the pounding in the mortar. No indication of remains of a spore could be seen even in the early 1- and 2-celled stages. They were bits of mycelium free from all tissue connections. This fact would indicate that the mycelium is not deeply imbedded in the pectin of the intercellular region.

An occasional filament can be traced back into strands inside the tuber tissue. Such a filament will be seen to break up in the culture medium into the rods of *B. megaterium.* In the two figures shown, the dried tissue had been covered with agar at 11:30 A.M. When examined and photographed at 2:30 P.M. the filament was projecting into the medium and had thrown off a long bud, which lay parallel to it. The growth was rapid during the first half hour, but a series of five exposures were made of which only one, that at 4:30 is reproduced. At this time the true point of origin of the cluster of bacilli could be determined only by referring back to the earlier stage.

A careful study of such filaments germinating from tissue showed that in every case the part in the tissue lay close to the margin and that all connection with the hyphae of the cells had been broken. In no instance was a germination observed from the end of a hyphae extending unbroken back into the tissue.

Occurrence in other parts of the potato plant and in other plants.—No extended efforts were made to isolate *B. megaterium* from other parts of the potato or from other plants. It was noted that, with the same technique used, this organism was common in disinfected sweet potatoes and also in potato roots after they had been washed and dipped in 95 percent alcohol from 10 to 15 seconds before crushing them up in the mortar. The same is true of garden carrots.

Since the Burbank Russet potatoes were mature and had been in storage for at least four months, the same technic was used on small Bliss' Triumph tubers taken fresh from the soil and larger tubers of the same variety grown in Florida. The same organisms appeared as when the storage tubers had been used.

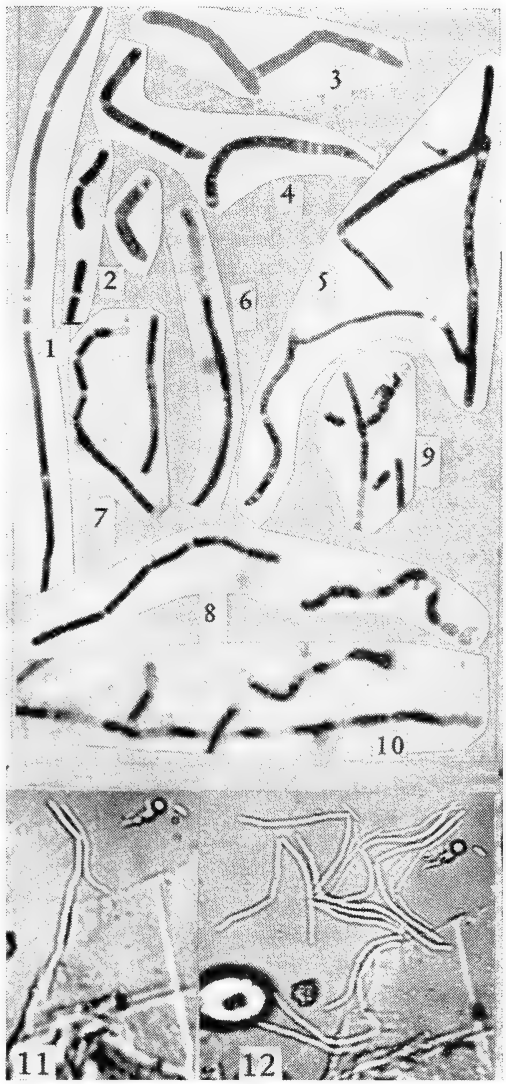
[3] The writers wish to thank Dr. Nathan R. Smith for the additional information that the three isolations sent to him after this work was done readily produced spores on the ordinary beef agar.

Sheath on the hyphae in the tubers.—No note was taken of the occurrence of a sheath on the filaments stained in the intercellular regions of the potato tuber by Lutman (*7*), but such a sheath shows distinctly in many of the photographs, especially those of sections of mature tubers. In one of the illustrations of these filaments in the turnip, the tube is shown cut through in such a manner that the organism inside it was missed and the tube in part seemed empty. As shown in the same paper the enclosed filaments were also Gram-positive, although a special timing and technique had to be used to demonstrate them.

Tissue cultures with sterile material.—The interior of healthy plants was formerly held to be free from bacteria and sterile. Tissue cultures have been made of many organs without any evidence of bacterial growths on the bits of tissue. The reason for this apparent freedom from bacteria is due, so far as *B. megaterium* is concerned at any rate, to its marked aerobic habit. It will not grow in a stab in a solid culture medium to a depth of much more than two millimeters. In tissue-culture technique, the bits of tissue are covered with the nutrient fluid to a depth sufficient to stifle the growth of this highly aerobic species. If growth should start, the colonies would be so small owing to lack of oxygen that they have been overlooked.

Systematic position of the organism.—The question arises at once in the mind of any systematist of microorganisms of the naming and grouping of the pleomorphic species which lives part of its life as a branching mycelium inside plants and breaks up into short, motile bacilli in culture media.

In the sixth edition of Bergey's *Manual of determinative bacteriology* (*1*), Order II. *Actinomycetales* Buchanan has as family I. *Mycobacteriaceae* Chester, a single genus: I. *Mycobacterium* Lehmann and Neumann. This group contains many important organisms such as those associated with tuberculosis and leprosy. These organisms are also filamentous at times but break up readily into nonmotile rods. *Bacillus megaterium* would not fit into such a genus since the organisms are typically motile. It can not be regarded as a true Actinomyces, although it has a sheath and the resting spores are similar to those of the latter group. No member of the Actinomyces



Figs. 1–12.—Pleomorphic forms assumed by *Bacillus megaterium* in culture media, aqueous crystal violet stain: 1, "Runner" type with vacuoles; 2, types of short bacilli; 3, budding, and 4, bud almost separated; 5, extreme branching with variation in size of branches; 6, end of filament with empty "sausage" skin; 7–10, resting spores formed by fragmentation, spores still enclosed or connected by clear-walled sheath; 11, filament arising from a bit of potato tuber tissue with a parallel branch or bud at right, taken at 2:30 P.M.; 12, same, at 4:30 P.M. (Figs. 1 and 5–9 magnified 1,100 times, Figs. 2–4 magnified 1,350 times; 11 and 12, 400 times.)

is known, however, to have a motile stage or endospores. The intermediate position of this microorganism is clearer than its disposition in any present classification.

The middle lamellae.—To the botanist the fundamental contribution of these observations is that the denser material between plant cell walls is not a chemical (calcium pectate), as suggested by Mangin who discovered these bodies, but living microorganisms that may be grown in culture media outside the plant. Further, the old conception that the interior of plants is sterile is not tenable. The role which these microorganisms play in the physiology of the higher plants will have to be determined by future experiments, but the abundance of the filaments in enlarged roots (carrots, beets, turnips) and tubers (potato, sweetpotato, and Jerusalem artichoke) suggests the formation of some type of growth-stimulating substances. It may be pointed out that the invasion of the cork cambium of young potato tubers by a similar microorganism stimulates the cork cells to produce hypertrophied tissue known as common or corky scab.

ADDENDUM

The day following the receipt of the manuscript for transmittal to the editors of the JOURNAL, word was received of the fatal illness of the senior author of this paper. In the meantime it has come to my attention that G. B. Sanford recently published a paper in *Scientific Agriculture*, vol. 28, pp. 23–25, 1948, entitled *The occurrence of bacteria in normal potato plants and legumes*. In addition, I am informed that a manuscript by Tervet and Hollis along the same line has been accepted for publication and will shortly appear in *Phytopathology*. These and former papers seem to leave little doubt that healthy plant tissues may contain microorganisms. The frequency of their occurrence and their function still remain to be discovered. —NATHAN R. SMITH.

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ZOOLOGY.—Hesperochernes thomomysi, *a new species of chernetid pseudoscorpion from California.*[1]

C. CLAYTON HOFF, University of New Mexico. (Communicated by EDWARD A. CHAPIN.)

Pseudoscorpions are common in the nests of burrowing rodents. The species found in rodent nests have received relatively little attention, however, perhaps as a result of difficulties encountered in making species determinations in the groups to which most of these forms belong. In the present paper, a new species of the genus *Hesperochernes* is described from the nest of *Thomomys monticola* from California, the description being based on material submitted by Dr. Edward A. Chapin, of the United States National Museum. The type specimens mounted on microscope slides are deposited in the National Museum. As a result of our very inadequate knowledge of chernetid

[1] Received June 7, 1948.

pseudoscorpions, the inclusion of the generic description is considered advisable.

Suborder Monosphyronida Chamberlin, 1929
Family Chernetidae Menge, 1855

Genus **Hesperochernes** Chamberlin, 1924

Hesperochernes Chamberlin, Pan-Pacific Ent. **1:** 89–90. 1924; Beier, Das Tierreich **58:** 174. 1932; Hoff, Bull. Illinois Nat. Hist. Survey. (In press.)

Cephalothorax clearly longer than wide; carapace granular, with two transverse carapacal furrows. Tergites divided, granular. Palpi stout, femur with well-defined pedicle. Setae of body and palps usually lightly, but clearly clavate. Flagellum with four setae; setae *b* and *sb* of hand of chelicera thickened and denticulate. The sensory seta *ist* of the fixed chelal finger is distal to *est; st* of the movable chelal finger is found nearer to *t* than to *sb*. The tarsus of the fourth leg is without a true sensory seta, although a short toothed pseudotactile seta may be present.

Genotype: *H. laurae* Chamberlin, 1924 (through original designation).

Hesperochernes thomomysi, new species

Female.—The description of the female is based on two specimens, the holotype and a paratype. The measurements of various structures of the holotype are followed in parentheses by the corresponding measurements of the paratype whenever the two differ significantly. Body stout, light yellowish brown in color; palpi deeper brown, often golden brown to reddish brown, and moderately stout; body length 3.1 (2.7) mm. Carapace light yellowish brown to golden brown, transverse furrows well marked, posterior furrow nearer to the posterior carapacal margin than to the median furrow; posterior margin well rounded, lateral margins convex and passing without interruption into the anterior margin; carapace somewhat subtriangular in shape; dorsal surface of carapace virtually smooth except for very fine netlike markings, lateral surfaces moderately granulate; setae very numerous, well scattered, terminally denticulate, not clavate; eyes not distinguished; length of carapace 0.98 (0.92) mm, width 0.96 (0.83) mm; greatest width in the posterior half of the carapace. Abdomen oval in shape, very stout; tergal halves well separated by rugose and nonsclerotic areas; setae small, mostly nonclavate, terminally denticulate, similar to those of the carapace; each tergal half of tergite 1 with eight or nine setae, maximum number of setae on any tergal half is 10; tergite 11 not divided; surface of tergites marked much like the dorsal surface of the carapace. Ventral surface of abdomen with the sternal halves well separated medially; halves of sternite 4 with two setae in holotype, with three or four in paratype; each half of sternite 5 with seven to nine setae; maximum number of setae on any sternal half is 10; setae longer and more conspicuous than on the tergites; setae of sternites acuminate. Each anterior stigmatic plate with two or three acuminate setae; each posterior plate with one seta; pleural membranes with rugose and wavy parallel striations. Abdomen 2.1 (1.8) mm in length; width 1.73 (1.42) mm.

Chelicera: Yellow in color; moderately stout; 0.28 (0.27) mm long, base 0.17 mm wide; subbasal seta of base stout, widened, with numerous terminal and subterminal denticulations; basal seta more slender and with fewer denticulations, in some instances the denticulations are difficult to observe; internal and laminal setae very long and acuminate; surface of hand unsculptured except for a roughened area in the region of the insertion of the subbasal seta; flagellum with the largest seta distinctly bladelike, a little curved, and deeply serrate along one margin throughout almost the entire length of the blade; the two proximally placed setae subequal in length and each longer than half the length of the longest blade of the flagellum. Fixed cheliceral finger with well-developed lamina exterior, markedly convex near the center of the finger; apical tooth with three or four small and rounded denticles on the inner margin; inner finger margin with four or five denticles in the distal third of the margin, the distal two heavy and conical in shape, the proximal two or three more weakly developed and more retroconical; serrula interior with four distal plates free, others fused. Movable finger stout, little curved; 0.22 (0.23) mm long; serrula exterior of 17 to 19 ligulate plates, of which the proximal one is much longer than the others; galeal seta almost reaching the tip of the galea; galea with a stout base, antlerlike, with six somewhat curved branches confined to the distal half of the galea; apical tooth sclerotic and terminally

bicuspid; subapical lobe just basal to the apical tooth and distal to the base of the galeal seta, somewhat smaller than the apical tooth and frequently blunt.

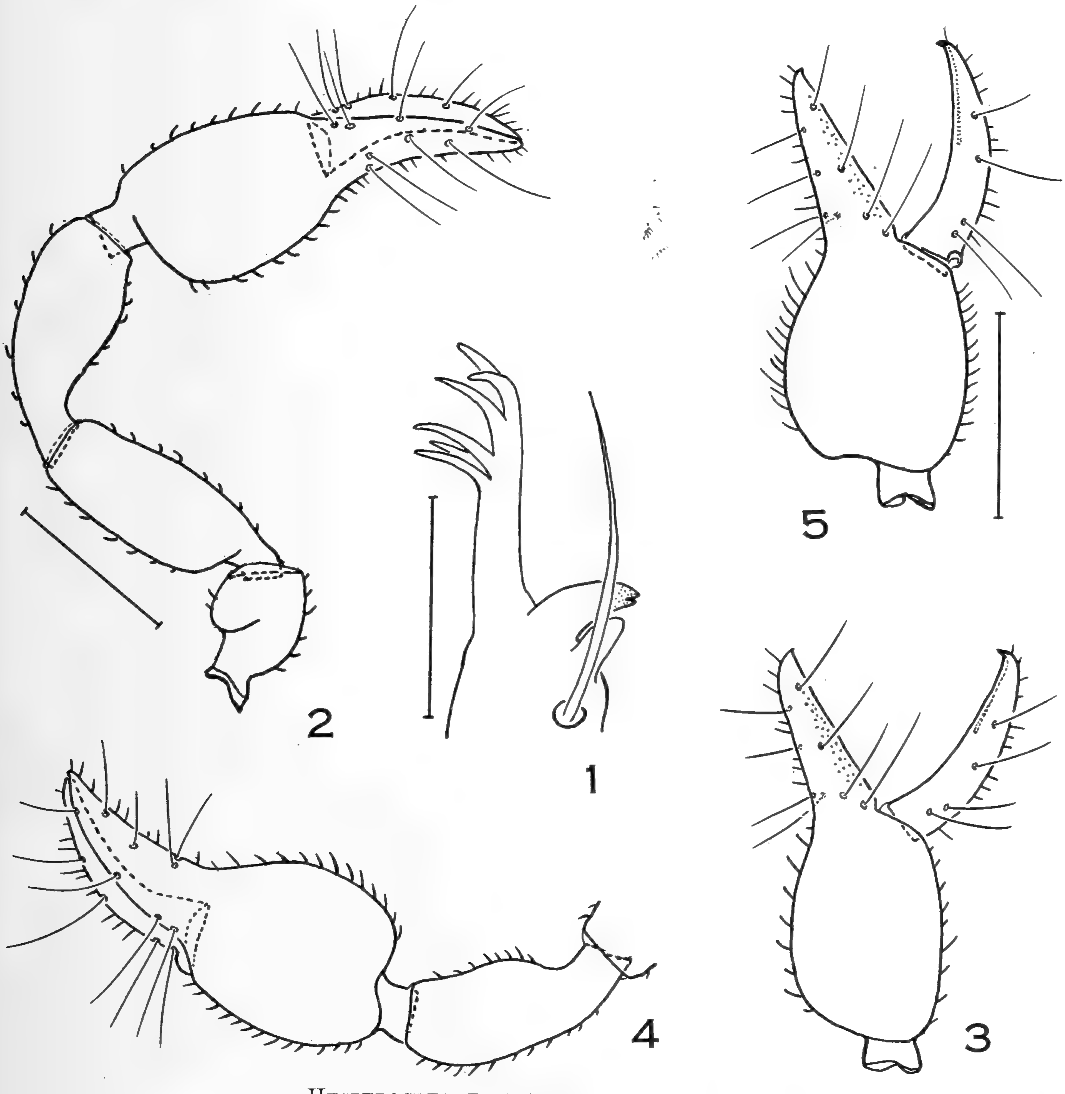
Palpus: Moderately stout; surface of podomeres virtually unmarked and almost nongranulate except the maxilla; maxilla with weakly granulate surface and with numerous, short and stout setae, many of which have a few terminal denticulations; setae of podomeres in general subclavate and fairly stout on the proximal podomeres, longer, more slender, and nonclavate on the distal podomeres, each seta with a few terminal and subterminal denticulations; investing setae of chelal fingers acuminate; color variable, deep golden brown in holotype to light yellowish brown in paratype. Maxilla 0.48 (0.43) mm long, 0.34 (0.31) mm wide. Trochanter somewhat club-shaped, pedicle stout, two protuberances present, 0.44 mm long, 0.26 (0.24) mm wide in strict dorsal view. Femur with pedicle about as long as wide and well set-off from the rest of the podomere; extensor margin very little convex in the center, more convex near the ends; flexor margin weakly S-shaped femur widest near the center; greatest over-all length 0.74 (0.73) mm, length along either the extensor or flexor margin 0.68 (0.66) mm; width 0.275 (0.26) mm. Tibia with stout pedicle; flexor margin somewhat evenly convex except towards the distal end and in the region of the pedicle; extensor margin markedly convex near the ends; length 0.67 (0.64) mm, width 0.28 (0.26) mm. Chela with hand stout and fingers fairly well separated from the hand; extensor margin of hand flatly convex, flexor margin more or less evenly and distinctly convex; hand somewhat bulging in the flexor-basal angle and the pedicle far displaced towards the extensor margin; fingers gently curved and narrowed regularly and decisively from base to distal end; length of chela 1.14 (1.08)mm, width 0.43 (0.40) mm; length of hand 0.57 (0.55) mm; length of movable finger 0.57 (0.55) mm. From the side, the chela has a subrectangular hand, with the pedicle almost at the ventral-basal corner; ventral margin weakly and evenly convex; dorsal margin more convex and, with the basal margin, forming a well-rounded angle; depth of hand 0.43 (0.41) mm; fixed finger nearly straight, more or less cone-shaped in outline and broadly joined to the hand; external aspect of fixed finger near the inner margin is conspicuously granulate; the movable finger less stout but well curved, especially in the proximal third of the finger. Each finger with between 40 and 45 marginal teeth, all with cusps and contiguous; the marginal teeth of the distal end of the row more acute and with better developed cusps than those at the proximal end of the row; fixed finger with four or five internal and four or five external accessory teeth, all confined to the distal one-half of the finger; movable finger with two internal and three to five external accessory teeth, all found in less than the distal half of the finger; nodus ramosus of movable finger somewhat nearer tactile seta *t* than *st* in the holotype and nearer *st* than *t* in the paratype. Tactile setae as usual in the genus; *st* varying from a little (holotype) to considerably (paratype) closer to *t* than to *sb*; other tactile setae as shown in the figure.

Legs: Moderately stout; yellowish brown, often very light in color; surface of podomeres nongranular; setae except on tarsi fairly heavy, subclavate, with numerous subterminal and terminal denticulations; setae of tarsi like those of other podomeres basally and on the extensor surface, but distally and on the flexor surface relatively stout and acuminate; terminal tarsal claws well curved and slender. First leg with trochanter subquadrate, 0.185 mm long, 0.147 mm deep; pars basalis distally deepened, flexor margin more or less evenly rounded, length measured along the flexor margin 0.245 (0.24) mm, depth 0.175 (0.165) mm; pars tibialis with both flexor and extensor margins evenly convex, deepest near the center, length measured along the extensor margin 0.37 (0.36) mm, depth 0.147 (0.135) mm; tibia with extensor margin weakly S-shaped, flexor margin somewhat evenly convex, 0.405 (0.39) mm long, 0.118 (0.105) mm deep; tarsus subcylindrical, flexor margin a little convex, length 0.41 (0.40) mm, depth 0.083 (0.076) mm. Fourth leg with trochanter having a very weakly but evenly convex flexor margin, extensor margin much more convex, especially in the central portion, entire podomore somewhat quadrate in outline, length 0.34 mm, depth 0.195 (0.178) mm; pars basalis subtriangular, flexor margin weakly convex to almost straight, length measured along the flexor margin 0.27 (0.25) mm, depth 0.18 (0.17) mm; pars tibialis with

flexor margin nearly straight, extensor margin evenly or flatly convex, deepest near the center, length measured along the extensor margin 0.52 (0.50) mm, depth 0.20 (0.18) mm; length of entire femur 0.73 (0.70) mm; tibia shaped much as in the first leg but much more slender, very weakly S-shaped or extensor margin virtually straight except near the proximal end, length 0.60 (0.61) mm, depth 0.125 (0.12) mm; tarsus subcylindrical but the flexor margin somewhat convex, podomere deepest near the center, length 0.47 (0.46) mm, depth 0.095 (0.09) mm.

External genitalia: Simple; anterior operculum with 14 closely clustered setae, posterior to which is found a group of 13 (11) well-spaced and well-separated setae; posterior operculum with a single row of eight (13) setae.

Male.—The collection contains four males, one of which is designated the allotype. The



Hesperochernes thomomysi, new species

Fig. 1.—Tip of movable finger of chelicera, female holotype; scale 0.05 mm. Fig. 2.—Dorsal view of palpus, female holotype; scale 0.5 mm. Fig. 3.—Lateral view of chelal hand, female holotype; scale as in Fig. 2; marginal and accessory teeth omitted. Fig. 4.—Dorsal view of tibia and chela of palpus, male allotype; scale as in Fig. 5. Fig. 5.—Lateral view of chelal hand, male allotype; scale 0.5 mm; marginal and accessory teeth omitted.

measurements given are the limits of range of the four specimens. In general, male similar to female but smaller; body length 2.0–2.4 mm; carapace 0.76–0.82 mm long, 0.62–0.73 mm wide. Abdomen usually with seven setae on each half of tergite 1, other tergal halves usually with eight or nine setae; each half of sternite 4 with three to four acuminate setae, each half of sternite 5 with seven to ten setae, maximum number of setae on any sternal half is ten, in some specimens only eight or nine; anterior stigmatic plate with three setae, posterior plate with one seta; length of abdomen 1.19–1.60 mm.

Chelicera: Much as in the female; serrula exterior with 17 to 19, but usually 18, ligulate plates; length of chelicera about 0.24 mm, width of base between 0.14 and 0.15 mm, length of movable cheliceral finger 0.18–0.195 mm.

Palpus: Variable but much like that of the female except podomeres a little smaller, tibia and chela distinctly stouter and of different shape, and a tendency for the flexor surfaces of the femur and tibia to be very weakly granulate. Some specimens with palpi dark reddish-brown in color. Maxilla 0.38–0.43 mm long, 0.27–0.28 mm wide. Trochanter 0.37–0.39 mm long, 0.195–0.23 mm wide. Femur with flexor margin more S-shaped and extensor margin more irregular and more flattened near the center than in the female; greatest length 0.57–0.66 mm, length measured along either margin 0.53–0.58 mm, width 0.23–0.25 mm, greatest length between 2.5 and 2.8 times the width, length along either margin 2.25 to 2.5 times the width. Tibia with slight to well-marked concavity just proximal to the distal end of the flexor margin, length 0.53–0.59 mm, width 0.24–0.26 mm, length 2.2 to 2.3 times the width. Chela very stout; extensor margin evenly and markedly convex, the flexor margin more rounded and convex, giving the hand a subspherical appearance when viewed from the dorsad; flexor-basal corner distinctly swollen; fingers from the dorsad as in the female; length of chela without pedicle 0.97–1.07 mm, width 0.415–0.52 mm, length 2.05 to 2.35 times the width; length of hand 0.50–0.53 mm, length of movable finger 0.53–0.62 mm. From the side, the chela of the male relatively deeper than in the female, depth 0.44–0.55 mm; ventral margin evenly but not greatly convex, dorsal margin bulging and rounded, especially in the area where it merges with the basal margin; marginal teeth about 40, varying from 35 to 45; accessory teeth extremely variable, each row with three (in one instance two) to as many as eight accessory teeth; on movable finger tactile seta *st* is nearer to *t* than to *sb* and the nodus ramosus in most individuals is conspicuously nearer to *st* than to *t*; tactile setae somewhat variable in the fixed finger but in general as shown in the figure.

Legs: Conspicuously smaller than in the female, otherwise very similar; some podomeres possibly a little more slender but limited material precludes definite statement regarding the condition in all podomeres. First leg with trochanter 0.14–0.155 mm long, 0.12–0.135 mm deep, length 1.15 to 1.25 times the depth; pars basalis 0.185–0.2 mm long, 0.135–0.15 mm deep, length 1.3 to 1.4 times the depth; pars tibialis 0.29–0.31 mm long, 0.12–0.13 mm deep; length 2.35 to 2.5 times the depth; tibia 0.31–0.35 mm long, 0.09–0.105 mm deep, length 3.3 to 3.4 times the depth; tarsus 0.32–0.345 mm long, 0.07–0.075 mm deep, length 4.55 to 4.75 times the depth. Fourth leg with trochanter 0.25–0.275 mm long, 0.135–0.155 mm deep, length 1.7 to 1.85 times the depth; pars basalis 0.195–0.22 mm long, 0.135–0.155 mm deep, length 1.35 to 1.4 times the depth; pars tibialis 0.39–0.46 mm long, 0.155–0.175 mm deep, length 2.45 to 2.65 times the depth; entire femur 0.54–0.62 mm long, length 3.35 to 3.65 times the depth; tibia 0.45–0.55 mm long, 0.10–0.122 mm deep, length 4.4 to 4.7 times the depth; tarsus 0.39–0.41 mm long, 0.08–0.09 mm deep, length 4.55 to 5.0 times the depth.

External genitalia: 20 to 25 fine and acuminate setae on the anterior operculum anterior and lateral to the genital slit; the posterior operculum with four setae in a row immediately posterior to the genital slit and 16 to 25 setae, many in a single row but a few scattered, behind the four setae; chaetotaxy variable.

Tritonymph.—Measurements are given as the limits of variation of five individuals. Measurements of the legs are not included since these may be considered of little importance to the species description. Tritonymph much like the female but smaller and lighter in color; length of body 1.9–2.5 mm. Carapace possibly a little more granulate than in the female and

the investing setae a little more clavate; length of carapace 0.67–0.76 mm, width 0.51–0.62 mm. Abdomen with each half of tergite 1 having five to seven setae, other tergal halves usually with six to eight setae; each half of sternite 4 with two to five setae, of sternite 5 with six or seven setae; maximum number of setae on any sternal half is seven; each anterior stigmatic plate with one or two setae; posterior stigmatic plate with one seta; abdomen otherwise much as in the female; length 1.35–1.8 mm, width 0.9–1.4 mm.

Chelicera: General structure like that of the female. Tactile seta *b* noticeably smaller than *sb*, less stout and with very few denticulations or appearing acuminate perhaps as a result of being in a position unfavorable for study; inner margin of fixed finger sometimes with three or six teeth but usually four or five; galea relatively stouter than in the female, four or five antlerlike branches in the distal half; 14 to 16, usually 15, plates in the serrula exterior; length of movable cheliceral finger 0.17–0.18 mm.

Palpus: In general like that of the female but on the average lighter in color; podomeres smaller in size; tibia and femur stouter; setae much less numerous but of the same type as in the adult; surface of all podomeres, especially the flexor surfaces, moderately granular; pedicle of all podomeres relatively stouter than in the adult; pedicle of chela nearer the center of the base of the hand than in the adult; trochanter 0.28–0.32 mm long, width 0.175–0.20 mm, length 1.6 to 1.75 times the width; femur 0.48–0.54 mm long, 0.195–0.21 mm wide, length 2.25 to 2.55 times the width; tibia 0.40–0.49 mm long, 0.20–0.23 mm wide, length 2.0 to 2.25 times the width; chela 0.72–0.85 mm long, 0.27–0.32 mm wide, length 2.6 to 2.7 times the width; length of hand 0.34–0.43 mm, depth of hand 0.31–0.34 mm; movable chelal finger 0.39–0.45 mm in length. From the side, the chelal hand is much more like that of the female than the male; marginal teeth of fingers nsually between 30 and 35 in a number; accessory teeth variable, one to four in each row. Movable chelal finger with nodus ramosus just proximal to tactile seta *t*; one tactile seta absent; the center one of the three tactile setae may be closer to the basal (*b* or *sb*?) or to the distal seta *t*. Fixed finger with *ist* missing; other tactile setae much as in the adult except *it* is relatively farther removed from *et*.

Legs: Lighter in color, with fewer setae, smaller, and stouter than in the adult, but otherwise very similar. Tarsus of first and fourth legs somewhat fusiform, narrowed distally.

Type Locality.—Fresno County, Calif. The female holotype, one female paratype, the male allotype, three male paratypes, and five tritonymph paratypes were taken from a nest of *Thomomys monticola* on January 27, 1947, at Huntington Lake, elevation 7,000 feet, by I. G. Ingles.

Remarks.—Our new species, *H. thomomysi*, may be separated from other species of the genus by the shape and size of the palpal podomeres as well as other characteristics. The species seems somewhat closely related to *H. sanborni* (Hagen, 1869) from the New England states and to *H. pallipes* (Banks, 1893) from California. No difficulty is experienced in separating this form from the two closely related species on the basis of characteristics given in the above description. From the type of the genus, *H. laurae* Chamberlin, 1924, our form is easily separated by the smaller and stouter palpal podomeres. Only two species, *H. laurae* and *H. pallipes*, have been reported previously from California.

ZOOLOGY.—*Three new eastern millipeds of the family Xystodesmidae.*[1] RICHARD L. HOFFMAN, Miller School of Biology, University of Virginia. (Communicated by E. A. CHAPIN.)

Through the kindness of Drs. Edward A. Chapin, Waldo L. Schmitt, and Alexander Wetmore, I have been enabled to carry on extended work on the diplopod collection of the U. S. National Museum. During the course of identifying and arranging material, a number of undescribed species have been discovered. Three of these are described below, representing three genera of the large Holarctic family Xystodesmidae.

In one instance personal field work has resulted in the independent discovery of one of the new forms, and in this case my specimen has been designated holotype, since it is a fresh one and in better condition. It has been deposited in the National Museum collection.

Two of the species are of considerable interest from a systematic standpoint, and remarks on their relationships are included. A key to the known species of the genus *Tucoria*, based on males, is also appended.

The figures illustrate the configuration of the left male gonopod, and are made from cephalic and mesial aspects following removal and orientation of the appendage. Setae have been removed in order to show basal structure.

Apheloria intermedia, n. sp.

Figs. 1, 2

Diagnosis.—Male gonopod with lateral process produced upward in the manner of *Deltotaria*, lateral spine scarcely perceptible at end; mesial process low, rounded; blade of telopodite forming a loose curve, tip of blade not bent out of line with rest of the structure.

Description of male holotype.—Length 34, width 8.2 mm. Body rather slender, gently tapering caudad, more abruptly cephalad. Segments 4 through 14 of full width.

Collum large, almost semicircular in dorsal aspect, caudal margin almost straight (lateral portion swept slightly forward), cephalic margin rather evenly rounded and swept back. Marginal ridge perceptible on lateral extremities of collum.

[1] Received July 28, 1948.

Second and third segments with cephalolateral corners of keels widely rounded, marginal ridges well developed. Posterior edges of tergites straight except in being tapered forward on keels.

Segments 4 through 14 subsimilar, anterior corners rounded, slightly lobed cephalad; lateral margins of keels somewhat convex in dorsal aspect, marginal thickenings prominent, smooth. Posterior corners of keels not produced; caudal margins of keels but little caudad of rest of tergite across body. Dorsum well arched, keels not especially wide, but continuing slope of dorsum, particularly on the anterior half of the body. Repugnatorial pores dorsal in position.

Segments 15 through 19 with keels becoming increasingly produced caudad, those of nineteenth being small, somewhat angular lobes.

Anal segment triangular in dorsal aspect, somewhat longer than broad; distally truncate. Anal valves inflated, smooth, glabrous; mesial ridges conspicuous. Preanal scale semicircular, terminal lobe sharp, lateral tubercules small.

Bases of last pair of legs almost in contact. Sternites between other legs wide, those posterior to seventh pair of legs smooth and glabrous, not produced into lobes or spines. Trochanti and femora bearing large and sharp ventral spines. Distal tarsal joint equal in length to basal two, much shorter than femur. Legs bearing slender curved terminal claws.

Coxae of second legs of males with the usual cylindrical distally flattened seminal processes.

Gonopods large, protruding from large oval aperture; at rest retracted snugly against sternites and lying against one another, usually with the blades interlocked. Lateral process unusual for the genus, strongly produced upward suggesting the development found in the genus *Deltotaria;* basal spine represented by a slight acumen at the terminal end of the process; mesial process low, rounded, rather large, the cephalic margin very setiferous. Blade of telopodite highly arched, slightly compressed dorsoventrally toward the end; distal portion not bent either laterally or mesially.

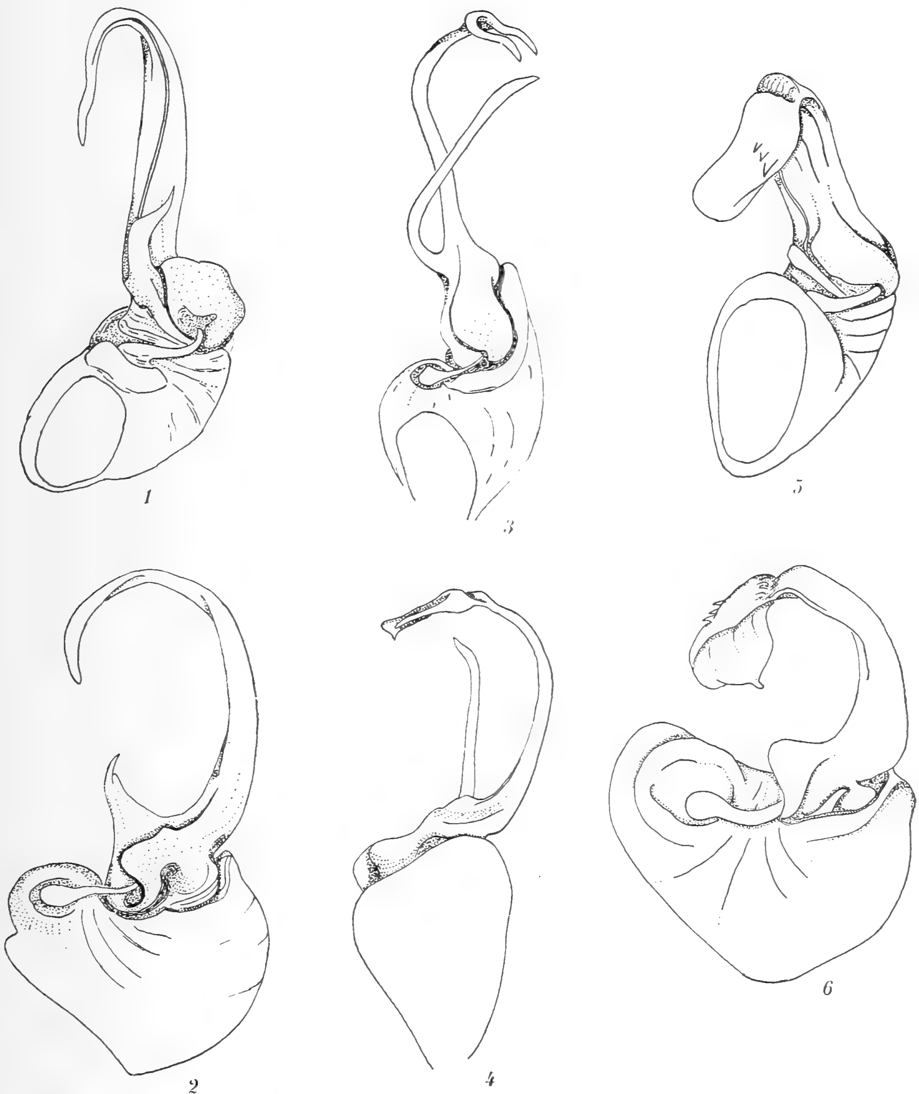
Color in life not known, appearing to have been blackish with most if not all of the dorsal surface of keels yellow or red.

Description of female allotype.—Agreeing in most respects with the male. Differs as follows: Body more arched and compact; keels of segment 19 more rounded; femoral spines longer. Length 35, width 7.6 mm.

Type locality.—Asheville, Ashe County, N.C.

Type specimens.—Male holotype and female allotype, and a paratype of each sex in the U. S. National Museum collection, no. 1833. These specimens were collected in August 1896, presumably by Dr. L. M. Underwood, of Syracuse University, although no collector is indicated on the label. Underwood collected many specimens in the Southeast during the summer of 1896.

Remarks.—The discovery of this strikingly disjunct form of *Apheloria* is of considerable importance. In addition to providing a link between the hitherto widely separated *coriacea*



Figs. 1–6.—1, Cephalic view of left gonopod of male type, *Apheloria intermedia*, from Asheville, N. C.; 2, mesial view of same; 3, cephalic view of left gonopod of male paratype, *Nannaria morrisoni*, from Page County, Va.; 4, mesial view of same; 5, cephalic view of left gonopod of male type, *Tucoria viridicolens*, from Greensburg, Ky.; 6, mesial view of same. Pubescence has been removed from all structures figured.

and *trimaculata* sections of the genus (hence the specific name), *A. intermedia* seems to represent an ancestral stock from which the genera *Apheloria* and *Deltotaria* have been derived. It furthermore inhabits an area where one would expect just such a form to be found —western North Carolina, from whence many species of both genera have been described.

Detailed information on the relationships and phylogeny of this species is reserved for inclusion in a future publication treating the entire genus *Apheloria*.

Nannaria morrisoni, n. sp.

Figs. 3, 4

Diagnosis.—Size small; processes between fourth pair of legs greatly developed; gonopods of male with main branch of telopodite distally bifurcated, and lateral branch long, flattened, and directed mesiad.

Description of holotype.—Length 21, width 4.1 mm. Body with sides subparallel, both ends abruptly tapering; segments 3 through 16 of full width.

Collum large, trapezoidal, almost as long as succeeding two segments; lateral marginal thickenings large; lateral extremities slightly rounded; posterior margin straight across body.

Segments 2 through 4 similar, dorsal marginal ridges large, posterior edges of keels swept forward, caudal margins of tergites slightly concave. Segments 5 through 15 subsimilar, anterior corners rounded, posterior corners right-angled or somewhat acutely angled, with a weakly indicated dentation; tergites about same width at edges of keels as at midline, and keels well separated, giving impression of evenly rectangular segments; segments 16 through 19 with keels becoming more produced caudad, those of segment 19 into subangular lobes about equal in length to one-half the distance between their bases. Dorsum not strongly arched, keels rather small, continuing slope of dorsum, the lateral edges directed cephaloventrad. Repugnatorial pores very small, not in a noticeable depression, on the ventral side of the edge of the keel.

Anal segment triangular in dorsal aspect, its sides concave, the usual subterminal lateral tubercules prominent, the tip more truncate than usual, directed ventrad. Anal valves subplane, finely wrinkled, the usual setiferous tubercules not observed, mesial ridges very large. Preanal scale large, subtriangular, the median terminal lobe largest and well set off.

Bases of last pair of legs well separated. Legs of segments 8 through 18 subsimilar, sternites broad, glabrous, produced into conspicous sharp lobes at bases of legs; coxae and trochanti unarmed, femoral spines large, becoming more elongated caudad. Those of last several pairs of legs as long as femora; tarsal joints with terminal as long as basal two, almost as long as femur, tarsal claw short, strongly curved at right angle to axis of legs.

Coxae of second pair of legs with the usual seminal projections, these unusual in becoming swollen distally; sternites between fourth pair of legs with two greatly developed lobes, these being as long as seminal projections but evenly tapered distad. Pregenital limbs hairy and lacking femoral armature, tarsal claws heavy, blunt.

Gonopods project from a large oval aperture, directed cephalad between bases of fifth pair of legs; *in situ* with the telopodite blades crossed at midline, the entire appendages twisted so that the small accessory branch is lowermost, in contact with the sternites. When in use the gonopods are forced out slightly and stand parallel to each other and perpendicular to the plane of the sternites, with the smaller branch lateral in position. Coxal joint of gonopod relatively undifferentiated, higher (longer) than broad; telopodite with a somewhat elongated basal portion, mesial process or shoulder large, heavily setiferous, merging into blade of the appendage; lateral process small, inconspicuous, much lower than mesial; a narrow groove between the two, extending distad; blade of telopodite long, slender, curved cephalad over base, distally bifurcated into a larger, lateral, apically mucronate branch and a smaller, spiniform, mesial one. A secondary division of the telopodite, arising from the lateral side of the basal portion is elongated, flattened slightly expanded distally, and bent mesiad from the base across the larger branch. For exact configuration of the gonopods, consult the accompanying figure.

Color in life as follows: tergites dark olive, suffused with black, a suggestion of a median dark line on the posterior part of the body; anterior and posterior corners of keels, lateral ends of collum, and distal half of anal segment

bright pink; top of head light brown to about level of antennal sockets, front of head, including sockets and first antennal segment very dilute brown; antennae mostly olive with last article dark gray in striking contrast. Underparts entirely whitish gray.

Type locality.—Saddle Hollow, about 3 miles west of Crozet, Albemarle County, Va., elevation about 2,000 feet, on the east side of the Blue Ridge. Dominant vegetation *Liriodendron tulipifera*, *Quercus* spp., and *Cercis canadensis*.

Type specimens.—Male holotype, U.S.N.M. no. 1834, collected on March 28, 1948, by the writer; two male paratypes collected in April 1936 by Drs. Irving Fox and J. P. E. Morrison, U.S.N.M. no. 1836.

Remarks.—The paratypes were collected along Skyline Drive, 4 miles north of Thornton Gap, Page County, Va., and still another locality is afforded by a female tentatively assigned to this form, collected on the Blue Ridge about 5 miles southeast of Charlestown, Jefferson County, W. Va. The range is thus seen to be restricted to the Blue Ridge Physiographic Province between the Potomac and James Rivers, but of course the species may be found elsewhere as well. The Blue Ridge in Virginia is occupied by several distinct, probably endemic, forms of animals, so that the addition of this milliped to the list is interesting but not surprising.

Nannaria morrisoni is so manifestly different from most of the other members of the genus, such as *media, minor, conservata, fowleri,* and *terricola*, that its inclusion in that genus may be questioned. I place it here for the following reasons: except for the greatly produced sternal processes *morrisoni* can be separated from other forms only by the small size and nature of the gonopods. These processes are present in other species as small lobes and probably will be found to vary in size in the different forms. As regards the gonopods, while they seem very disjunct, I am describing elsewhere a species from Mountain Lake, Va., which is perhaps intermediate between *morrisoni* and the other species. Judged from the material I have examined, and from species figured in the literature, *Nannaria* can be divided into several groups on the basis of the gonopods—one based on *media* and its relatives, one on *scutellaria*, and one to include *morrisoni* and the related species mentioned above. Recognition of those groups as genera may become convenient when numerous species have been described in *Nannaria*. A thorough treatment of the genus is much needed, and in fact is contemplated, but must be preceded by extensive field work.

This species is named in honor of Dr. Joseph P. E. Morrison, of the U. S. National Museum, whose diligence and interest in securing myriapods incidentally to collection of land snails have enriched the Museum collection with much valuable material.

Tucoria viridicolens, n. sp
Figs. 5, 6

Diagnosis.—Size small for the genus; gonopods of the *splendida* type, apical process small, upper part of telopodite distad of constriction bearing three sharp teeth.

Description of holotype.—Body robust, length about 40 mm (specimen broken), width 9.3 mm; sides subparallel, segments 4 through 14 of full width; body tapering abruptly cephalad, very gradually caudad. Tergites well arched, keels wide, continuing slope of dorsum.

Collum crescentic in dorsal aspect, caudolateral edges tapering slightly cephalad; lateral marginal thickenings absent.

Segments 2, 3, and 4 similar, caudal margins of tergites straight, of keels swept forward, smoothly rounded; dorsal marginal thickenings present only on fourth, very obscure.

Segments 5 through 14 similar, caudal margins of keels produced slightly caudad, caudolateral corners of keels not produced into lobes; sides of keels smooth, rounded, somewhat convex; cephalolateral corners broadly rounded off. Dorsal marginal thickenings rather poorly developed, smooth; upper surface of keel finely granular, of dorsum slightly wrinkled.

Segments posterior to twelfth agree with those preceding, but with keels becoming increasingly produced caudad, and segments becoming narrower; keels of the nineteenth form short, bluntly triangular lobes.

Anal segment triangular in dorsal aspect, tip slightly truncated, two tiny subterminal lateral tubercules present. Anal valves slightly inflated, smooth, the setiferous tubercules almost obsolete; mesial ridges very prominent. Preanal scale broadly triangular.

Bases of last pair of legs separated. All sternites smooth, glabrous, very weakly pro-

duced into lobes at bases of legs, those posterior to gonopods broad, those between third, fourth, and fifth pairs of legs with conspicuous, low, pointed lobes. Coxae small, unarmed; trochanti weakly armed; femora with well developed spines. Terminal tarsal joint shorter than proximal two, but slightly longer than the unusually short femur.

Gonopods large, conspicious, projecting cephalad and in contact mesially. Mesial process large, very setiferous, area immediately posterior on the mesial side trilobed; lateral process very small, not produced apically; blade of telopodite flat, curved forward over base, strongly constricted about one-third its length from distal end; terminal portion bent laterad, very flattened, a small apical projection, outer surface with three conspicuous sharp teeth in an oblique row. Configuration of gonopods as shown in the accompanying drawings.

Second pair of legs with the usual cylindrical distally truncate seminal lobes. Pregenital limbs hairy, without spines on the femora; tarsal claws short, heavy, blunt.

Color faded from long preservation, but appears to have been black or very dark brown in life with caudolateral halves of the keels orange or yellow.

Type locality.—Trace Creek, Greensburg, Green County, Ky.

Type specimen.—Male holotype, U.S.N.M. no. 1835, collected by L. Garman on July 15 (no year given).

Remarks.—This species is the smallest member of the genus to be described so far. Its relationships seem to be clearly with *T. kentuckiana* and *T. splendida* rather than with *T. dynama.*

Following is a key to the known species of *Tucoria*, based on males. Females of all of the species are not known, and the genitalia of the others not figured.

KEY TO SPECIES OF TUCORIA

1. Lateral process of male gonopod small, inconspicuous, not produced upward nto any sort of spine or projection 2
   Lateral process of male gonopod larger, produced upward into a noticeable, occasionally sharp, projection 3
2. Apical process on telopodite of gonopod small, simple; distal portion of telopodite with three denticles on outer side .... *viridicolens*, n. sp.
   Apical process larger, curved, slightly crenulate; distal portion of telopodite without denticles .... *kentuckiana* (Causey)
3. Lateral process of gonopod produced into a broadly triangular spine; distal portion gently curved; dorsum black, trimaculate with yellow .... *splendida* (Causey)
   Lateral process of gonopod produced into an upright slender peg, distally slightly acuminate; distal portion of telopodite strongly recurved toward base, much expanded; dorsum with yellow cross bands .... *dynama* Chamberlin

ZOOLOGY.—*More about Mexican urocoptid mollusks.*[1] PAUL BARTSCH, U. S. National Museum.

The tireless efforts of Miss Marie E. Bourgeois in personally collecting mollusks and interesting her friends in this group have brought to light two species of urocops not heretofore known to science. These are here diagnosed. A detailed description of *Oligostylus hegeweschi* is also made possible from topotypes that she collected.

Oligostylus hegewischi Bartsch

In my paper *Notes on some Mexican urocoptid mollusks, with the description of new species* in this JOURNAL.[2] I renamed *Bulimus truncatus* Pfeiffer, 1841 (preoccupied by *Bulimus truncatus* Bruguière, 1792), calling it *Oligostylus? hegewischi*. No material from the type locality being available, I placed a query after the generic designation. I closed my remarks under that species with the statement: "It is to be hoped that Miss Bourgeois will rediscover it at Angangueo." Miss Bourgeois took this to heart and paid a visit to Angangueo, Michoacán, and secured a fine series of specimens of this species and donated a splendid lot (No. 488018) to the U. S. National Museum which makes it possible for me to confirm the statement made in my paper and to remove the question mark after the generic name, for these topotypes prove to be a typical *Oligostylus*.

[1] Received July 8, 1948.
[2] Journ. Washington Acad. Sci. **37**: 284–288, 1947.

Miss Bourgeois tells us that the specimens were found "well buried in the leaf mold, or humus (perhaps they were depositing eggs) under dead agave leaves, always well buried in the earth, near the roots, or center of almost every agave (or maguey plant)." These plants, she says, "strange to say, were far up on the mountainside of Cerro Guadalupe, just north of town." This mountain contains no limestone, and the superintendent of the mines told her that there was no limestone within 40 kilometers of Angangueo, which is 2,800 meters above sea level.

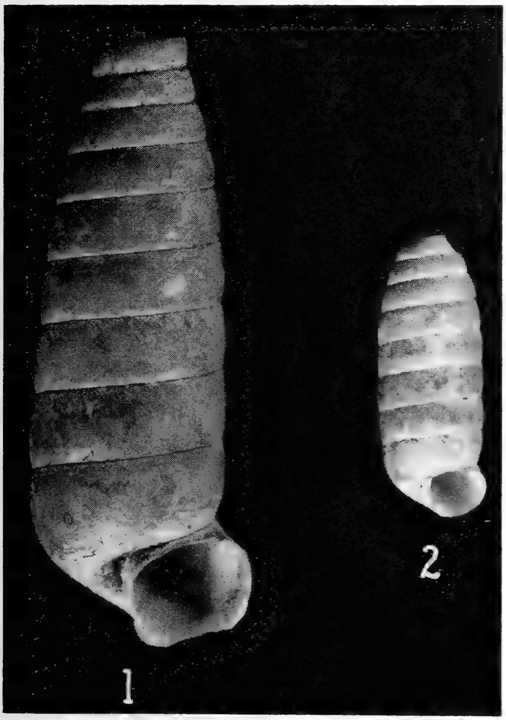


Fig. 1.—*Coelocentrum anconai*, n. sp. Fig. 2.—*Liocentrum wilmoti*, n. sp.

To my translation of Pfeiffer's description I may now add:

The eggs are white, symmetrically oval, finely, microscopically granulose, measuring in length 4.2 mm, diameter 2.3 mm.

The first 5 whorls of the shell form a cylindrical apex; beyond this the shell gains very gradually. The apex is blunt. The first turn and a half are smooth; the whorls thereafter become axially ribbed and are at first weakly, then more strongly, retractively curved. The ribs are sinuous and average about half the width of the spaces that separate them. They are strongest in the middle turns and weaken toward the end, where the surface shows irregular, small malleations. Fifty of them are present on the last turn of the young specimens here figured. Suture well impressed. Periphery of the last whorl weakly angulated. Base short, with a small umbilical chink, well rounded, and marked by the continuations of the axial ribs. Aperture subcircular. Peristome white, thickened at the outer margin, adnate to the preceding whorl. The columella is slender. The shell on the later turns is chestnut brown, gradually paling to horn color near the summit of the whorls, contrasting markedly with the yellowish-white peristome.

The young specimen figured has 10.1 whorls and measures: Length 10.3 mm, diameter 4.1 mm. The adult shell figured has 7.5 whorls remaining and measures: Length 29.2 mm, diameter 10 mm.

This species resembles *Oligostylus mariae* Bartsch but is readily distinguished from it by its much weaker ribs and by the malleation of the later turns.

Coelocentrum anconai, n. sp.

Fig. 1

Shell large, elongate-turreted. Our bleached specimens are yellowish white with the peristome buff. Early whorls decollated. The 9.5 whorls remaining in the type are slightly rounded and crossed by numerous closely spaced, retractively curved axial ribs, which are best developed near the periphery and summit of the whorls, becoming decidedly reduced on the middle of the turns. More than 200 of these are present upon the penultimate turn. Suture weakly impressed. Periphery obscurely angulated. Base well rounded, with an umbilical chink, marked by the feeble continuation of the axial ribs. Aperture subquadrate. Peristome slightly thickened and reflected at the edge, free for about 1 mm from the preceding whorl. There is a slight carina present on the outside at the posterior angle. A fold is apparent on the columella deep within the aperture. Columella narrow with a decided twist, bearing distantly spaced, sigmoid, and sublamellar folds. The type, U. S. N. M. no. 589052, has 9.5 whorls remaining and measures: Length 61 mm; diameter 20 mm. It was collected in the

woods of Ocote, at Ocozocoantla, Chiapas, and donated to the Museum by Prof. I. Ancona, whose name I am pleased to attach to the species.

A second specimen somewhat less perfect is in Professor Ancona's collection.

The large size and slender columella will readily distinguish this from the other known species of *Coelocentrum.*

In the narrowness of the columella it resembles *Coelocentrum pfeifferi* Dall from the same general region. That species, however, is very much smaller. The type measures: Length 38 mm, diameter 16 mm. The largest specimen, a topotype, having 8.2 whorls, measures: Length 44.8 mm, diameter 16 mm.

Liocentrum wilmoti, n. sp

Fig. 2

Shell of medium size, white. The truncated specimen almost cylindric. The remaining whorls are slightly rounded and marked by numerous slightly curved, retractively slanting axial ribs separated by spaces about as wide as the ribs, of which 140 are present upon the penultimate whorl. These riblets pass undiminished from the summit to the periphery. Suture slightly impressed. Periphery with a weak keel. Base short, well rounded, with an umbilical chink, marked by the continuation of the axial ribs. Aperture obliquely subcircular with a columellar fold deep within; peristome adnate to the preceding whorl at the parietal wall. Columella slender, twisted, smooth. The type U.S.N.M. no. 589051, was collected by George Wilmot in Oaxaca, on a mountainside near the auto highway, between the cities of Oaxaca and Tehuantepec. It has 8.1 whorls remaining and measures: Length 27.3 mm; diameter 10.4 mm.

In outline it somewhat resembles von Martens' *Coelocentrum championi* from the Cerro Zunil, Guatemala, differing from this, however, in the aperture, which is solute in von Martens' species, the size of columella, and other details.

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The thirty-third edition of the Academy's Directory, or "Red Book," commemorating the fiftieth anniversary of the founding of the Academy and containing pictures of 499 of its members, was published in July and distributed to the membership. This is the first Directory so illustrated to appear. Carrying as it does halftone reproductions of portraits of many of the leading scientists and engineers of the Washington area, it forms a pictorial and historical record that should increase in interest and value over the years.

As usual, The Directory carries a complete list of Academy members and members of affiliated societies, with addresses. Also given are names of the officers, text of the bylaws and constitutions, and brief historical résumés of the organization of each of the 19 societies affiliated with the Academy. The book aggregates 300 pages.

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ANTHROPOLOGY.—*Glossary of names used in colonial Latin America for crosses among Indians, Negroes, and Whites.*[1] Hensley C. Woodbridge, Champaign, Ill. (Communicated by T. D. Stewart.)

Society in colonial Spanish and Portuguese America was divided into several groups, each of which had its own privileges and social position. First and foremost were the *chapetones*[2] or *gachupines*[3] or the Spaniards from Spain, to whom the important government and church positions were usually given. Next were the *criollos,*[4] who were those born in the colonies of European or Spanish parents. The Indians, the Negroes, who were often slaves, and the offspring of the mixing of these races—White, Indian, and Negro—were the other important groups of this diversified society.

This brief note is not interested in the superior position occupied by the first two classes of society mentioned above, nor will it be attempted here to trace the reasons for the antagonisms, which existed between the *gachupines* and the *criollos.* Excellent studies already exist dealing with the history and position of the Indian[5] and Negro[6] in colonial society, and there seems to be no reason to review these facts even briefly.

Yet only a few studies have appeared that have attempted to define or explain the various designations applied to the offspring of racial mixtures.[7] It is interesting, though confusing, to note that these terms vary from region to region, century to century, and that the same word can have a variety of meanings, which might then cause one to agree with Aguirre Beltrán (1946, p. 177) that these "erudite classifications had the defect of being unintelligible and impracticable, as the logical product of minds filled with affectation." However, these terms cannot be ignored, for they appear in Spanish and Portuguese works, written since the sixteenth century, as well as in the works of Humboldt, Mantegazza, and other foreigners who have written of their travels in Spanish and Portuguese America. It shall, therefore, be the purpose of this

[1] Received August 16, 1948.

[2] The origin of *chapetón* is still an undecided matter, though all would accept the definition "the European or Spaniard, who has recently arrived in the New World." The word was evidently first used at the beginning of the seventeenth century and was more commonly used in South America than in Spanish North America, where the term *gachupín* was more frequent.

[3] The bibliography of *gachupín* or *cachupín* is enormous; authorities differ on whether it is derived from the Portuguese, *cachopo,* or from the Aztec words *cactli* and *tzopinia,* which mean in the contracted form "he who pricks with or wears spurs." The present writer can only state that the majority of some 30 studies consulted favor the Aztec derivation of the word.

[4] The word *criollo* was introduced to Spanish America by Negro slaves and is to be found in the works of Garcilaso de la Vega, el Inca, early in the seventeenth century. The *Dic. leng. esp.* (1947, p. 369) notes that the word has the following meanings: (1) "Offspring of European parents, no matter where born," (2) "Negro born in America in contrast to the one born in Africa," (3) "Used to designate Americans, the offspring of Europeans." In Spanish America the last of these three meanings is the most frequent one.

[5] For a bibliography on this subject see Haring (1947, pp. 360–362).

[6] The volumes by Saco (1938), Aguirre Beltrán (1946), Ramos (1943), Tannenbaum (1947), and Freyre (1946) are useful for the study of the Negro in this hemisphere. Haring (1947, pp. 362–363) gives a very short bibliography, while the *Journal of Negro History* and *Phylon* can often be consulted with profit.

[7] The historian usually uses the word *caste* to designate the offspring of these racial mixtures. See the studies by Nicolas León and Laureano Vallenilla Lanz listed in the bibliography. The White, Indian, and Negro races are the only ones here considered, though it is true that a few Chinese are to be found in Mexico as early as the first part of the seventeenth century.

glossary to define well over a hundred terms denoting racial mixture; most of these are Spanish, a few are Portuguese, though studies on this subject in Portuguese appear to be rather rare.[8]

One must make a few general remarks about the number of individuals who were the product of racial mixture. Humboldt (1941, **2:** 30–31) notes that in Spanish America, as a whole, 45 percent of the population was Indian; 42 percent was composed of mixed races; 19 percent of members of the White race; and 4 percent of Negroes. He and Bonpland[9] estimated the population of Venezuela at the beginning of the nineteenth century at 800,000; of which 12,000 were *chapetones;* 200,000 *criollos;* 406,000 persons of mixed races; 62,000 Negro slaves, and 120,000 Indians. In other words, more than half of the Venezuelan population was composed of mixed races.

In regard to New Spain, or Mexico, Aguirre Beltrán (1946, especially p. 237) has conclusively shown, from a study of the various historians, censuses, and other data, that the percentage of the White and Negro population remained almost stationary and that the population formed of racial mixtures constantly grew. His tables show that the racial mixtures formed 0.44 percent of the population in 1570; 22.6 percent in 1646; 36.6 percent in 1742; 38.7 percent in 1793; and 39.5 percent in 1810.

The above statistics are indicative of the numerical position of these mixed groups, though it is true that in Brazil the proportion might have been higher than the 42 percent mentioned above, but in Chile and the Río Plata area, for a variety of historical reasons, the proportion of inhabitants offspring of racial intermarriage was correspondingly smaller.

The various racial mixtures were considered to possess different physical and moral characteristics. Alcedo (1786–89, **5:** 184) notes that the *zambo* was the group most scorned because of the perverse customs of its members; while Humboldt (1941, **2:** 140) notes that 'the *mulatos* are distinguished by the violence of their passions and by a peculiar talkativeness. Viceroy Enríquez in the sixteenth century states that the *mulatos pardos* have the three following characteristics: Great fecundity, outstanding strength, and cleverness. He finds that the *mestizos* are, on the whole, well behaved, agile, and courageous. The Spanish writers of the colonial period had no respect at all for the Negro and for the racial mixtures formed from the union of Negro and Indian. They were called lazy, vile, insolent, and other insulting names, which later came even to be applied to the *mulatos* and *mestizos* "because they are universally so evilly inclined." However, after Mexico became independent, Lucas Alamán[10] wrote that "these castes, defamed by the laws, condemned by prejudice, were nevertheless the most useful portion of the population."

Space forbids the listing of the so-called characteristics of each racial group. The racial mixtures were plagued with the same diseases which carried off so many Indians and Negroes. Smallpox, dysentery, *matlazahuatl*[11] and other diseases identifiable only with difficulty made enormous inroads on the population. The Indian, Negro, and racial mixtures appear to have been able to resist malaria and yellow fever to a much greater degree than the White element of the population.[12]

Passing from one group to another was carefully watched, though at the end of the viceroyalty in Mexico members of certain of the racial mixtures passed to the *criollo* and Indian groups. It is impossible here to study the economic, social, and legal reasons which would cause an individual to prefer to be a member of one caste rather than another. Suffice it to mention that the *mulatos* were subject to the payment of tribute and a head tax, while the *mestizos* were exempt from these taxes (Aguirre Beltrán, 1946, pp. 154, 172).

[8] Aguirre Beltrán (1946, p. 178) notes that "the Brazilian classification ought to have been as complicated as that used in the Spanish colonies; nevertheless, there does not exist a systematic study of Brazilian nomenclature."

[9] Quoted by Baralt (1939, p. 361).

[10] Quoted by Aguirre Beltrán, p. 190.

[11] The identification of *matlasahuatl* has aroused great controversy. The writer purposely refrains from presenting a 2-page bibliography on the subject and desires only to point out that the majority of the recent writers such as Aguirre Beltrán (1946) and Ashburn (1947) identify it as typhus.

[12] These two paragraphs have been based on chapter 10 of Aguirre Beltrán (1946).

No detailed studies have been found concerning the social position of the individual castes. Haring (1947, p. 218) notes that "free *mulatos* and *zambos* were regarded as peculiarly inferior" and that they were forbidden to appear on the streets after dark, carry arms, have Indians as servants, hold public office or be admitted to the craft guilds; Laureano Vallenilla Lanz (1921, p. 113) remarks that members of the castes could not be lawyers, priests (this applied especially to the *pardos*), or members of the religious orders, nor could they wear jewels, silks, or laces or use carpets in the churches, swords, pistols, or umbrellas; Millau (1947, pp. 42–43) states that the Negroes and *mulatos* were, for the most part slaves and that they served as water carriers; as for the Indians and *mestizos*, their occupations were working in the brick kilns and serving on the ranches and as cartmen. At the end of the colonial régime certain of these groups were permitted to serve in the militia.

The glossary that follows is based on the terms denoting the offspring of racial mixture to be found in the various volumes mentioned in the bibliography as well as in a series of tables or collections of portraits to be found in various museums and reproduced by a number of authors.

Lack of space forbids the reproduction of the 15 tables[13] that have been gathered. However, the *Colección Larrauri Montaño* is as follows:

Father	*Mother*	*Offspring*
Spanish[14]	India	Mestizo
Spanish	Mestiza	Castizo
Spanish	Castiza	Spanish
Spanish	Negra	Mulato
Spanish	Mulata	Morisco
Spanish	Morisca	Albino
Spanish	Albina	Torna atrás
Spanish	Torna atrás	Tente en el aire
Indio	Negra	Cambujo
Chino cambujo	India	Lobo
Lobo	India	Albarazado
Albarazado	Mestiza	Barnocino
Barnocino	India	Sambaigo
Mestizo	Castiza	Chamiso
Mestizo	India	Coyote

No attempt has been made to deal with the various nicknames which were applied only to the Spaniards in the different parts of America, and the Portuguese portion of the glossary is decidedly weak in its nomenclature. The Spanish portion of the glossary is more complete than any of the attempts of this type that have preceded it. Though the glossary is composed chiefly of terms recorded as having been used in Mexico, the writer has attempted to list the other areas in which the word was used, if and when the word was found among the authorities studied.

[13] The *Colección Riva Palacio:* Humboldt (1941, 2: 113); León (1924, 47–48); Espasa (**34:** 1090–1094); Aguirre Beltrán (1946, pp. 175–176).

The *Colección del museo nacional de México:* Humboldt (1941, **2**: 113–114), Leon (1924, pp. 42–47); Aguirre Beltrán (1946, pp. 176–177).

The *Colección Larrauri Montaño:* Aguirre Beltrán (1946, p. 176); León (1924, p. 41).

Flores (1886–1888, **2**: 407) reproduces the table in *México a través de los siglos* (**2**: 472).

León (1924, pp. 39–40) gives the titles of the *Colección Magon,* while five other tables are to be found in his book: pp. 37–38; 40–41; 58–66; 29, 9.

Saco (1938, **2**: 68) reproduces Gumilla's table (n.d., p. 85); another table is to be found in Gumilla (n.d., pp. 86–87).

Saco (1938, **2**: 66–67) reproduces Unanue's tables (1940, pp. 50–51).

Jaime Jaramullo-Arango (1948) gives a brief list of 12 racial mixtures.

The Espasa enciclopedia (n.d., **34**: 1094) presents information from which a table of Brazilian nomenclature could be formed, and Aguirre Beltrán (1946, pp. 177–178) reproduces Saint Méry's French table.

Humboldt (1941, **2**: 142) also gives a short table.

[14] The above is an exact reproduction of the table, except that the word *español* has been translated by *Spanish. Barnocino* is probably another spelling for *barcino* and has so been treated in the glossary.

GLOSSARY

Term	Used in	Father	Mother	Remarks	Sources
Aça	Brazil	Negro	White	Another term for *mulato claro*	Ramos-Vivó, 359; Freire, 1: 94.
Abí te estás (or Allí te estás)	Mexico	Coyote	Mestiza		Santamaria, 1: 64; Espasa, 34: 1093; León, 21.
"	"	Coyote-mestizo	Mulata		Colección Riva Palacio.
"	"	No te entiendo	Indian		Flores, 2: 407
Albarazado (or albarasado alvarazado)	"	Cambujo	Mulata		Santamaria, 1: 74.
"	"	"	White		"
"	"	"	Indian		"
"	"	Tente en el aire	Mulata	25 percent White; 40.6 Indian; 34.4 Negro	Santamaria, 1: 74; León, 21.
"	"	Chino	Genizara		Santamaria, 1: 74; *Dic. hist. leng. esp.*, 1: 376; *Dic. leng. esp.*, 48.
"	"	Zambaigo	Indian		Espasa, 34: 1094.
"	"	Gíbaro	Mulata		Aguirre Beltrán, 176–177.
"	"	Lobo	Indian		Colección Larrauri Montaño.
"	"	Gíbaro	Indian		Flores, 2: 407; León, 9.
Albarazado	"	Coyote	Morisca		Colección Magon.
Albino	Mexico, Brazil, Santo Domingo	Morisco	White		Espasa, 34: 1094; Santamaria, 1: 75; *Dic. hist. leng. esp.*, 1: 383; *Dic. leng. esp.* ,50; León, 21.
"	Mexico	Negro	Negro	Negro born White	Malaret, 82.
"	Brazil	"	White	"Incorrect" designation for Brazilian *mulato*	Ramos-Vivó, 335.
Ariboco	Brazil	"	Indian		Saco, 2: 65.
Araçuaba	Bahia, Brazil	"	White	Regonal term for *mulato claro*	Ramos-Vivó, 359.
Barcino (or baroina, barzino barquina)	Mexico	Albarazado	Mulata		Espasa, 34: 1094; Santamaria, 1: 189.
"	"	"	Indian	12.5 percent white; 70.3 Indian; 17.2 Negro	Santamaria, 1: 189; León, 21.
"	"	"	White		Santamaria, 1: 189.
"	"	"	Mestiza		Colección Larrauri Montaño.
"	"	Gíbaro	Loba		Santamaria, 1: 189.
Bujamé	Ceara, Brazil	Negro	White	Regional term for mulato *claro*	Ramos-Vivó, 364.
Caboclo	Brazil	White	Indian	11 percent of the Brazilian population	*Gran. enc. port. bra.*, 5:278; Ramos-Vivó, 364–365; Freyre, 49, 67, 481
"	"	Indian	Negro		Freire, 2: 1131; Santamaria, 1: 248
Caboré	Brazil, especially the Sierra del Norte region	Negro	Indian		Freire, 2: 1131; Ramos-Vivó, 365; Freyre, 481; *Gran. enc. port. bra.*, 5: 279.
Caboverde	Brazil	"	"		Ramos-Vivó, 335.
Cabra	"	"	Mulata		*Gran. enc. port. bra.*, 5: 297; Freire, 2: 1132; León, 21; Espasa, 34: 1094.
"	"	"	White	Sometimes applied to *mulato*	Ramos-Vivó, 335, 365.
Cabre	"	"	Mulata		Santamaria, 1: 248.
Cabrocha	"			Feminine dark-skinned mestizo type	Freyre, 481.
Cafus (or cafuso, cafuzo)	"	"	Indian		Freire, 2: 1152; Freyre, 481; Ramos-Vivó, 365; Espasa, 34: 1092; Santamaria, 1: 264; *Gran. enc. port. bra.*, 5: 400.
"	"	"	Mulata		Freire, 2: 1152.
Calpamuato	Mexico	Zambaigo	Loba		Santamaria, 1: 276.
"	"	Mulato	Mestiza		"
"	"	"	Zamba		Flores, 2: 407.
"	"	Barcino	Indian	6.25 percent White; 85.15 Indian; 8.6 Negro	León, 22; Santamaria, 1: 276; Espasa 34: 1094.
"	"	Mulato	"		Colección Magon.
"	"	Sambaygo	Mulata		León, 9.
Calpamulo	"	Albarazado	Negro		Santamaria, 1: 276; *Dic. leng esp.*, 224; *Dic. hist. leng. esp.*, 2: 537
Cambujo	"	Lobo	Indian		Santamaria, 1: 281.
"	"	Chino	"	62.5 percent Indian; 37.5 Negro.	León, 21–22.
"	Río de la Plata region	Negro	"		Malaret, 197.
"	Mexico	"	"		*Dic. hist. leng. esp.*, 2: 564.
"	"	"	Albarazado		Santamaria, 1: 281.
"	Oaxaca, Mexico	"	White	Regional term for *mulato pardo*	Aguirre Beltrán, 169.

Term	Used in	Father	Mother	Remarks	Sources
Cambujo	Mexico	Zambaigo	Mulata		Santamaria, 1: 281.
"	"	"	China		*Dic. hist. leng. esp.*, 2: 564; *Dic. leng. esp.*, 229.
"	Various regions			Anyone with a dark complexion	Santamaria, 1: 281; Malaret, 197; *Dic. hist. leng. esp.*, 2: 564.
Cariboca	Brazil	White	Indian		Freyre, 483.
Carafuso	"	Negro	"		Ramos-Vivó, 335.
Castizo	Spanish-America	Mestizo	White		Malaret, 226; León, 22; Espasa, 12: 346; 34: 1093; *Dic. leng. esp.*, 269; *Dic. hist. leng. esp.*, 2: 854.
"	Brazil	"	Indian		Santamaria, 1: 334; Espasa, 34: 1094.
Castizo cuatraluo	Mexico	Mestizo	White		León, 22.
Cobrizo	Brazil	White	Indian		Ramos-Vivó, 366.
Cocho	Michoacán, Mexico			Regional term for *mulato pardo*	Aguirre Beltrán, 169.
Coyote	Mexico	Mestizo	"	25 percent White; 75 Indian	León, 22; Espasa, 15: 1447.
"	"	"	Cuarterón		Espasa, 15: 1447.
Coyote	"	Mulato	Barcina		"
"	"			Used for *mestizo pardo* and *mestizo blanco*	Aguirre Beltrán, 171.
Coyote-mestizo	"	Chamiso	Mestiza	36.3 percent White; 52.7 Indian; 11 Negro	León, 22.
Cuarterón	Spanish-America	White	Mestiza		Macias, 392; Malaret, 271; Saco, 2: 66; Unanue, 50; Santamaria, 1: 419; *Dic. leng. esp.*, 376.
"	Especially Cuba	"	Mulata		Ramos-Vivó, 367; Malaret, 271; Macias, 392; Santamaria, 1: 419
"	Colombia, Mexico, Brazil	"	Tercerona	87.5 percent White; 12.5 Negro	León, 22; Espasa, 34: 1094; Ulloa, 1: 30.
"	Mexico	Mulato	Mestiza		Colección Magon.
Cuarterón de chino	"	White	China	56.25 percent White; 6.25 Indian; 37.5 Negro	León, 22; Santamaria, 1: 419.
Cuarterón de mestizo	"	"	Mestiza	75 percent White; 25 Indian	"
Cuarterón de mulato	"	"	Mulata	75 percent White; 25 Negro	Santamaria, 1: 419.
"	"	Cambujo	China		León, 22.
Cuarterón de salta atrás	"	Tercerón	Negro		Santamaria, 1: 419; Espasa, 34: 1094.
Curiboca	Northern Brazil	White	Indian		Freyre, 483.
Chamiso (or chamizo)	Mexico	Coyote	Indian	22.6 percent White; 55.5 Indian; 21.9 Negro	León, 22; Santamaria, 1: 461.
"	"	Mestizo	Castiza		Colección Larrauri Montaño.
Chino	"	Indian	Zamba		Lenz, 1: 295; *Dic. leng. esp.*, 399.
"	Mexico	White	Morisca		Espasa, 17: 521.
"	Mexico, Cuba	Lobo	Negro	25 percent Indian; 75 Negro	Espasa, 17: 521; Santamaria, 1: 510. León, 22–23.
"	Cuba	Mulato	"		Malaret, 327; *Dic. leng. esp.*, 399; Santamaria, 1: 510.
"	Mexico	Salto atrás	Indian		Flores, 2: 407; León, 9; Espasa, 17: 521; Santamaria, 1: 510.
"	Peru	Mulato	"		Santamaria, 1: 510.
"	Argentina, Uruguay, Paraguay			Used for *mestizo*	Malaret 327; Mantegazza, 50; Santamaria, 1: 510.
"	Argentina	Negro	Indian		Santamaria, 1: 510; Espasa, 17: 521.
"	"	"	White		Santamaria, 1: 510; Espasa 17: 521.
Chino-cholo	Peru	"	Indian		Malaret, 327.
Cholo	Costa Rica			Indian or any dark individual	Malaret, 340; Santamaria, 1: 531.
"	Peru			Mestizo, with Indian features predominant	"
"	Chile, Peru, Ecuador, Bolivia, Argentina	Indian	White		*Dic. leng. esp.*, 401; Espasa, 17: 608; Malaret, 327; Lenz, 1: 311; Granada, 199; Roman, 2: 49.
Cholo-chino	Peru	Negro	Chinese or other oriental		Santamaria, 1: 531.
Español	Mexico	White	Castiza		Colección Larrauri Montaño.
"	"	"	Quinterona de mestizo	Sometimes used for *requinterón de mestizo*	León, 37–38.
"	"	Quinterón de mulato	Requinterona de mulato		"
Galfarro	"	Negro	Mulata	25 percent White; 75 Negro	León, 23.
Genizaro	"	Barcino	Zambaiga	17.975 percent White; 72.65 Indian; 9.37 Negro	León, 23; Espasa, 34: 1094; Santamaria, 2: 26.
Gente blanca	"	White	Requinterona de mulata	96.87 percent White; 3.13 Negro	León, 23.

Term	Used in	Father	Mother	Remarks	Sources
Gíbaro	Mexico, Puerto Rico	Albarazado	Calpamulo		Espasa, 34: 1094; Santamaria, 2: 145–146; *Dic. leng. esp.*, 744.
"	Mexico	"	Grifa		Espasa, 34: 1094.
"	"	Lobo	China	67.19 percent White; 12.5 Indian; 20.31 Negro	León, 23.
"	"	"	Mulata		León, 9.
"	"	Chino	"		Flores, 2: 407.
"	"	Calpamulato	Indian		Colección Magon.
"	"	Zambo	Grifa		Espasa, 34: 1094.
Grifo	"	Lobo	Indian	30 percent White; 20.7 Indian; 49.3 Negro	León, 23; Espasa, 34: 1094.
"	"			Used for *mulato*	Aguirre Beltrán, 177–178.
"	West Indies			Used to designate a colored person	Malaret, 440.
Harnizo	Mexico	Coyote	White	82.4 percent White; 12.5 Indian; 3.1 Negro	León, 23; Espasa, 34: 1094; Santamaria, 2: 90.
Hay te estás	"	No te entiendo	Indian	59.38 percent Indian; 15.62 White; 25 Negro	León, 9, 23.
Indio alobado	"	Mulato alobado	"		Aguirre Beltrán, 170.
Jagunço	Northeast Brazil			*Caboclo* with Negro blood	Ramos-Vivó, 373.
Jarocho	Veracruz, Mexico			Applied to *mulato pardo*	Aguirre Beltrán, 169; 178–179.
"	Mexico	Negro	"		León, 23–24.
Jíbaro (see Gíbaro)					
Ladino	Parts of South America	White	"		Boudin, quoted by Mantegazza, 50.
"	Central America; Tabasco, Mexico	"	"	Used for *mestizo*	Malaret, 498; Santamaria, 2: 168.
"	Mexico			Used by Indians to designate *mestizos* or Whites	Malaret, 498.
Limpio	"	White	Gente blanca	99 percent White; 1 Negro	León, 24.
Lobo	"	Negro	Indian		Espasa, 30: 1244; Ramos i Duarte, 337; Espasa, 34: 1094; León, 24.
"	"	Torna atrás	"		Colección Riva Palacio
"	"	Mulato	Salta atrás		Colección del museo nacional de Mexico.
"	"	Chino cambujo	Indian		Colección Larrauri Montaño.
"	"	Chino	Mulata		León, 9.
Lobo torna atrás	"	Lobo	Indian		Santamaria, 2: 189.
Loro	Chiapas, Mexico			See *mulato pardo*	Aguirre Beltrán, 169.
Mameluco	Brazil	White	"		Saco, 2: 65; Freyre, 489; Espasa, 34: 1092, 1095.
"	"			Generic term for every type of racial mixture	Freyre, 489.
Mestizo	Spanish and Portuguese America	"	"		León, 24–25; any of the dictionaries and encyclopedias.
"	Cuba	"	Negro	Used instead of *mulato*	Ramos-Vivó, 377.
"	Río de la Plata region			Generic term which includes the *zambo*, *chino*, and the *mulato*	Mantegazza, 50.
Mestizo blanco	Mexico	"	Indian		Aguirre Beltrán, 170–171
Mestizo castizo	"	Mestizo blanco	White		Aguirre Beltrán, 171.
Mestizo claro	Brazil	White	Indian (Caribe)		Espasa, 34: 1094.
"	"	"	Mestiza		"
Mestizo pardo (or mestizo amulatatado)	Mexico	Mestizo blanco	Mulata parda		Aguirre Beltrán, 171.
Mestizo prieto (or mulato amestizado)	"	"	Negro		"
Mestindio	"	"	Indian	25 percent White; 75 Indian	Aguirre Beltrán, 172; León, 24.
"	"	Mestizo	"		León, 58.
Mocorongo	Interior of Brazil	Negro	White		Ramos-Vivó, 377.
"	"	"	Indian		"
Morisco	Mexico	Mulato	White	75 percent White; 25 Negro	*Dic. leng. esp.*, 866; León, 25; Ramos-Vivó, 377; Santamaria, 2: 299.
			"		
Mulato	Cuba	White	Mulata		Santamaria, 2: 314.
"	Peru	"	Zamba		"

Term	Used in	Father	Mother	Remarks	Sources
Mulato	Argentina, Brazil, Mexico, etc.	Negro	White		Mantegazza, 50; Ramos-Vivó, 377; Macias, 875; *Dic. leng. esp.*, 876; Espasa, 37: 216; Aguirre Beltrán, 158, 167–170; Santmaria, 2: 314; León, 25; Alcedo, 126; Freire, 4: 3525.
"	Dominican Republic	Mulato	Mulata		Santamaria, 2: 314.
Mulato blanco	Mexico	Negro	White		Aguirre Beltrán, 167.
Mulato claro	Brazil	Negro with Semitic or Hamitic blood	"		Ramos-Vivó, 334.
Mulato lobo	Mexico	Mulato pardo	Indian		Aguirre Beltrán, 170.
Mulato morisco	"	Mulato blanco	White		Aguirre Beltrán, 167.
Mulato obscuro	"	Mulato	Indian	25 percent White; 25 Negro; 50 Indian	León, 25.
Mulato pardo	"	Negro	"		Aguirre Beltrán, 169.
Mulato prieto (or mulato anegrado)	"	"	Mulata parda		Aguirre Beltrán, 168–9.
Mulato tornatrás	"	Mestizo	Mulata		Espasa, 34: 1094; Santamaria, 2: 314.
Muxuango	Coastal Brazil	White	Tupi and Tapuyas Indians	May occasionally be part Negro	Ramos-Vivó, 377.
No te entiendo	Mexico	Tente en el aire	Mulata		León, 25, 9; Santamaria, 2: 335; Espasa, 34: 1093.
Octavón (or ochavon, octarón)	Mexico, Venezuela, Cuba	White	Cuarterona	87.5 percent White; 12.5 Negro; last two sources limit word's use to Cuba.	León, 25; Ramos-Vivó, 379–380; Saco, 2: 68; Gumilla, 85; Malaret, 597; Espasa, 39: 669; *Dic. leng. esp.*, 905.
Pardo	Cuba	"	Mulata		Macias, 935.
"	Brazil	Indian	"		Santamaria, 2: 411.
"	Argentina, West Indies, Brazil	White	Negro	Used for *mulato*, which has an unpleasant connotation for some people	Santamaria, 2: 411; Malaret, 624; Ramos-Vivó, 381; Espasa, 34: 1093–4 Freire, 4: 3820.
"	Brazil, Cuba, Puerto Rico	"	Indian	General designation for *mestizo* and colored individuals	Santamaria, 2: 411; Ramos-Vivó, 381, *Dic. leng. esp.*, 947.
Pardavasco	Brazil	Negro	"		Santamaria, 2: 411.
"	"	"	Mulata		Freyre, 493.
"	"	"	White	See *mulato*	Freire 4: 3820.
Paróara	"	Indian	"	*Caboclo*, who migrated north	Ramos-Vivó, 381.
Postizo	Mexico	Castizo	"		Santamaria, 2: 520; Espasa, 34: 1093; León, 25.
Puchuel	"	"	"		Espasa, 34: 1093.
"		Postizo	"		"
"		Mestizo	"		Santamaria, 2: 528.
Puchuela	Mexico	Octavón[15] indio	"	93.75 percent White; 6.25 Indian	León, 25.
"	Venezuela	Ochavón	"	All white, in regard to color	Gumilla, 85; Saco, 2: 68.
Puchuela de negro	Mexico	Octavón[16] Negro	"	93.75 percent White; 6.25 Negro	León, 25.
Quinterón	Mexico	White	Cuarterona		Santamaria, 2: 553; Malaret, 695.
"	"	"	Tercerón negra[17]	87.5 percent White; 12.5 Negro	León, 26.
Quinterón de mestizo	"	"	Castiza		Espasa, 34: 1093.
"	"	"	Cuarterona de mestizo	87.5 percent White; 12.5 Indian	León, 26.
Quinterón de mulato	"	"	Morisca		Espasa, 34: 1093.
"	"	"	Cuarterona de mulato		León, 26, 37–38.
Quinterón salta atrás	"	Cuarterón	Negro		Espasa, 34: 1094.
Requinterón	"	White	Quinterona		Santamaria, 3: 31.
Requinterón de mestizo	"	Quinterón de de mestizo	Requinterona de mestizo	93.75 percent White; 6.25 Indian	León, 26.
"	"	"	White		León, 37–38.
Requinterón de mulato	"	Quinterón de mulato	Requinterona de mulato	93.75 percent White; 6.25 Negro	León, 26.
Salta atrás (sometimes written salto atrás)	"	Chino	Indian	*Torna atrás* more common in Mexico	Santamaria, 3: 60.

[15] Though none of the sources consulted discuss this mixture as a separate term, it is obvious that it is 12.5 percent Indian and 87.5 percent White.
[16] *Octavón negro* is a more accurate way of expressing *octavon*, i.e., an individual 87.5 percent White; 12.5 percent Negro.
[17] This term does not appear to be discussed in the sources consulted; a tercerón Negro would be an individual 33.3 percent Negro and 66.7 percent White.

Term	Used in	Father	Mother	Remarks	Sources
Salta atárs	Mexico, Peru, Cuba	Cuarterón	Mulata	An individual whose parents are seemingly White, but who reveals by his color, skin, or features that in his remote ancestry there existed some Negro blood (Macias)	Alcedo, 164; Macias, 1074.
"	Mexico	White	Albina	95.75 percent White; 4.25 Negro	León, 26.
"	Venezuela	Indian	Mestiza	The offspring is so-called, "because instead of advancing somewhat (i.e., in whiteness), it goes backward to a great or lesser degree."	Gumilla, 85.
				So called "because instead of increasing its color, it goes backward; and the same 'throw back' occurs when the Indian and Negro races are mixed."	Saco, **2**: 69.
"	Mexico	White	White	Offspring with the characteristics of a Negro	Flores, 2: 407.
Salta atrás cuarterón	"	Negro	Tercerona	62.5 percent Negro; 37.5 White	León, 26.
Salta atrás quinterón	"	"	Cuarterona	43.75 percent White; 56.25 Negro	"
Sambayo (or sambaigo, sambahigo)	"	Cambujo	Indian	23.45 percent White; 75 Indian; 1.55 Negro	"
Saraça	Brazil			See *mulato claro*	Ramos-Vivó, 383.
Sarará	"			"	"
"	"			Light-colored Negro with kinky hair	Freyre, 497.
Septerón		White	Negro	12.5 percent White; 87.5 Negro; term coined by Saco	Saco, **2**: 67.
Tapanuna	"	Cafuzo	"		Espasa, **34**: 1094.
Tapuio	"	Civilized Indian	"		Ramos-Vivó, 385.
Tente en el aire[18]	Peru	Cuarterón	Cuarterona		Alcedo, 172.
"	"	Mulato	Mulata		"
"	"	Mestizo de indio	Mestiza de india		"
"	Mexico	White	Torna atrás		Colección Laurrauri Montaño.
"	"	Calpanmulato	Sambaygo		León, 9.
"	"	"	Cambuja		Santamaria, **3**: 155.
"	"	Indian	"	81.25 percent Indian; 18.75 Negro	Santamaria, **3**: 155; León, 26.
"	"	"	Loba		Santamaria, **3**: 155.
"	"	White	Requinterona		"
"	"	Gíbaro	Albarazada		Santamaria, **3**: 155; *Dic. leng. esp.*, 1209.
"	"	Zambo	Calpamulata		Espasa, **34**: 1093.
"	"	Salta atrás	Albarazada		Colección Magon.
"	"	Cuarterón	Mulata		*Dic. leng. esp.*, 1209.
Tercerón	Colombia, Mexico	White	"		Espasa, **60**: 1164; Ulloa, **1**: 29.
Tercerón (or cuarterón cuatraluo)	Brazil	"	"		Santamaria, **3**: 161; Espasa, **34**: 1093.
Tornatrás[19] (or torna atrás)	Mexico	No te entiendo	Indian		Santamaria, **3**: 204.
Torna atrás	"	White	Albina		Santamaria, **3**: 204.
"	"			Used for *salta atrás*	Alcedo quoted by León, 26.
Tresalbo (or tresavo)	Mexico, Peru	Mestizo	Indian	More common in Peru	Santamaria, **3**: 216; Espasa, **34**: 1093; Aguirre Beltrán, 177; León, 26.
Xíbaro	Brazil	Cafuso	Negro		Ramos-Vivó, 387.
"	"	Cariboca	"		"
"	"	Caboré	"		Freire, **5**: 5246.

[18] The comment of Alcedo (p. 172) accords with that of Saco (**2**: 69) who writes: "When a *mestizo* has offspring by a *mestiza* the offspring is *mestizo* too, and it is commonly called *tente en el aire*, because it neither advances nor retrogresses" (i.e., in color). Gumilla (p. 85) also advances the above idea as to the expression's origin.

[19] "*Torna atrás* implies a regression to Negro features in the offspring of the racial mixture, which modern investigations have demonstrated to be absolutely without basis" (Aguirre Beltrán, 177).

Term	Used in	Father	Mother	Remarks	Sources
Zambaigo (or zambaygo, zambayo, zambo de indio, sambaloo, sambaigo)	Mexico	Chino	Indian		Santamaria, **3**: 309; Espasa, **70**: 917; *Dic. leng. esp.*, 1316.
"	"	Lobo	"		Colección Riva Palacio.
"	"	Cambujo	"		León, 9; Flores, **2**: 407.
"	"	Barnocino	"		Colección Larrauri Montaño.
Zambo	Spanish and Portuguese America	Negro	"		Espasa, **70**: 920; Mantegazza, 50; Malaret, 829; Santamaria, **3**: 309; *Dic. leng. esp.*, 1316; Freire, **5**: 5255.
"	Chile, Colombia, Bolivia			Used for *mulato*	Mantegazza, 50; Malaret, 829.
"	Brazil			Used for *cabra*	Espasa, **34**: 1094.
"	Peru	Negro	White		Santamaria, **3**: 309.
"	"	"	Mulata	"The most despised of all racial mixtures because of their perverted customs"	Alcedo, 184.
Zambo	Peru	Negro	China		Saco, **2**: 67; Unanue, 51.
"	Mexico			Used for *cambujo*	Santamaria, **3**: 309.
"	Parts of Spanish America			Generic term for designating racial mixtures which are part Negro	Malaret, 829–830
Zambo cabra	Brazil	Mulato	Negro		Santamaria, **3**: 309.
Zambo claro	"	Cabra	Indian		Santamaria, **3**: 309; Espasa, **34**: 1094.
Zambo grifo		Mulato	Negro		Santamaria, **3**: 309.
Zambo prieto	Brazil, Peru, Mexico	Zambo	"		Santamaria, **3**: 309; Saco, **2**: 67; León, 27; Flores, **2**: 407; Unanue, 51; Espasa, **34**: 1093.
"	Brazil	Cabra	"		Espasa, **34**: 1094.
"	Cuba, Mexico	Lobo	"		Santamaria, **3**: 309; Espasa, **34**: 1093.
Zambo retorno		Mulato	"		Santamaria, **3**: 309.
Zambo de indio	Mexico	Indian	"	Used for *cambujo*	Alcedo, 184; León, 27.
Zambo de Negro	Northern South America	Quinterón	"		Ulloa, **1**: 30.
Zambo de mulato	"	"	"		"
Zambo de tercerón	"	"	"		"

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Espasa (see next item).

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BOTANY.—*Diagnosis of the* Elsinoë *on flowering dogwood.*[1]

Anna E. Jenkins, Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md., and A. A. Bitancourt, Instituto Biológico, São Paulo, Brazil.

In June 1948 we reported (*4*) the existence of a spot anthracnose affecting flowering dogwood (*Cornus florida* L.) and showed particularly by specimens then available that this had been found in Maryland, Virginia, North Carolina, South Carolina, and Georgia. Specimens have since been received from Delaware. In our preliminary account (loc. cit.) we described the symptoms of the disease. A diagnosis of the pathogen is here provided. This *Elsinoë* (Elsinoaceae, Myriangiales) not only constitutes another species of the genus on a tree host, but also it is the first to have been discovered on Cornaceae.

Elsinoë corni sp. nov., Jenkins and Bitancourt

Maculis in foliis paucis abundantibusve, usque 100 vel pluribus in lamina una, dispersis vel interdum nervisequentibus, circularibus usque angularibus vel irregularibus, typice parvis, usque ad 1 mm, rarius 1.5–2 mm in diam., superne prominentioribus et rubro-griseis, demum centro pallide flavo-griseo dehiscenti et lacunas vel lacerationes relinquenti; maculis in bracteis floralibus paucis numerosisve, dispersis, interdum in vel circa nervos dispositis, circularibus vel ellipticis, usque 1 mm in diam., singulis vel pauce aggregatis, pallide alutaceis, margine angusto brunneo usque purpureo et ultra zona indistincte alutacea circumdatis; cancris in petiolis, pedunculis, fructibus et caulibus parvis paucis vel plurimis, maculis foliorum similibus, planis vel valde elevatis, interdum leniter depressis. Ascomatibus comparative rarissimis, saepe 1–7 in superficie superiori maculae unae, circularibus usque leniter irregularibus, interdum coalescentibus, brunneis vel nigris, obscuratis, intraepidermi-

[1] Received August 25, 1948.

Fig. 1.—*Elsinoë corni,* pathogenic on flowering dogwood: *A,* Severely diseased shoot showing the typically small spots abundant on blade *a; b,* remnant of a diseased leaf; *c, d,* leaves that have become lacerated, *c* also showing infection along the midrib and *d* less distinct spotting on lower leaf surface; *e, e,* inconspicuous stem cankers; ×1. *B,* Petiole (*a*) and stem cankers (*e, e*), same as *A, e, e;* ×13. *C–E,* Various leaf spots, some showing "shot-holes," on upper third on a young leaf (*C*), basal part of a leaf including grooved petiole (*D*), intermediate region, with spotting on leaf margin; *C, a,* young ascomata (small dots); *E,* mature ascomata *a,* dotting pale centers of spots or remnants of them; ×13. *F,* Infected bract; ×1. *A–E,* Specimens from Highlands, N. C.; *F,* from Atlanta, Ga. Drawings by H. G. Stueler, based on photographs by R. L. Taylor and original specimens.

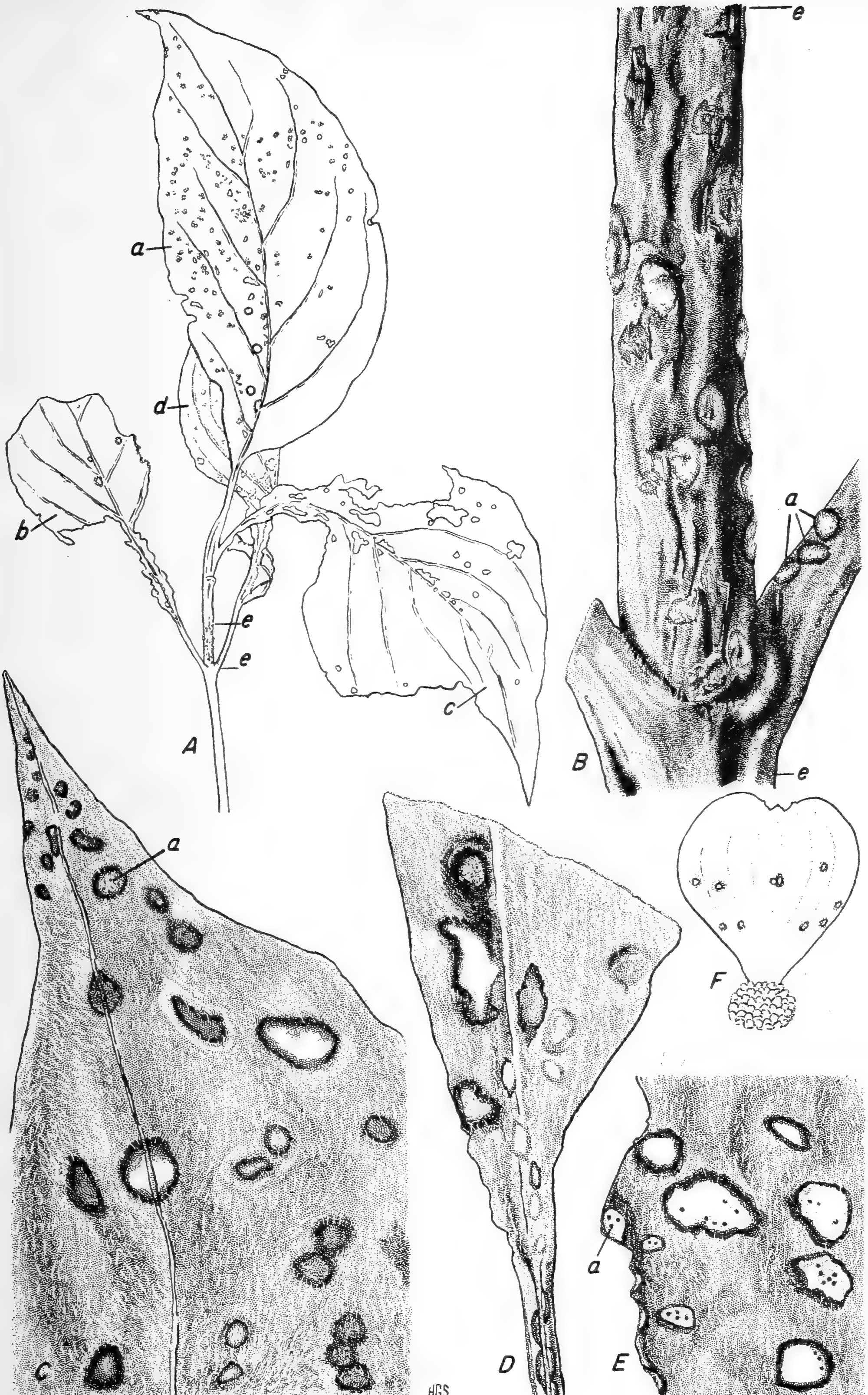

FIG. 1.—(See opposite page for legend.)

calibus, erumpentibus, 25–100μ in diam., usque 50μ crassis; epithecio tenui, atro-brunneo, pseudoparenchymate inferiori hyalino; ascis singulis vel multis, globosis, in stratum unum saepe dispositis, circa 16 mm in diam., usque octosporis; ascosporis 3-septatis, 12–15$\times$5μ, hyalinis; statu *Sphacelomate;* conidiophoris caespitosis, subulatis, hyalinis in palis dense compactis usque 39μ in diam., 20μ crassis, coloratis, conidiis oblongo-ellipticis, usque pyriformibus, 4.5–6$\times$2.5μ, hyalinis.[2]

Distribution.—On living leaves, small stems, floral bracts, and fruits of *Cornus florida* L. (Cornaceae), causing the disease named "flowering dogwood spot anthracnose," Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia.

Specimens examined.—DELAWARE: vic. Bridgeville and vic. Laurel, July 21, 1948, R. A. Jehle. MARYLAND: Beltsville, Plant Industry Station Grounds, September 1946; A. A. Bitancourt; R. A. Jehle collections, 1948,[3] vic. Somerset County, near Pocomoke, June 15; vic. Pocomoke, Worcester County, June 30; Pocomoke and vic. Hebron, July 16; vic. Denton, July 21; vic. Upper Marlboro, July 29; vic. Waldorf, vic. Helen, vic. Chaptico, and Charles County, 10 miles north of Cobb Island, August 6; vic. Wye Mills, August 12; Hurlock, August 13. NORTH CAROLINA: Highlands, Highlands Biological Laboratory Grounds, September 2 and September 5 (type U. S. Mycological Collections 90489; Secção de Fitopatologia, Instituto Biológico 5167), 1947, J. A. Stevenson. SOUTH CAROLINA: Georgetown, October 12, 1943, A. W. Blizzard. GEORGIA: Atlanta, April 1948, Comm. J. H. Miller (*Sphaceloma* stage on floral bracts; Savannah, August 4, 1939, A. A. Bitancourt).[4] VIRGINIA: Norfolk, May 9, 1948, H. T. Cook.

In connection with our *Myriangiales selecti exsiccati* we (*3*) have noted that usually the symptoms of diseases caused by *Elsinoë*, i.e., spot anthracnoses (cf. *2*), "are distinct and permit identification of the disease." The statement continues: "In some cases because of lack of fructifications it is particularly because of the lesions that the specimen is of interest."

The specimens of Elsinoë here cited, represent precisely this situation. The earliest (Savannah, Ga., August 4, 1939) is without fructifications and was taken because the lesions were typical of a spot anthracnose. The 12 ample specimens collected by Jehle were selected chiefly on the basis of symptoms. Ascomata are comparatively rare, although they are present on a few leaves of several different specimens. On some leaves of the gathering of August 13, they are actually numerous, with asci and ascospores visible as illustrated in Fig. 2, A. This contrasts with the specimen from Highlands dated September 5, in which many of the ascomata are overmature and asci cannot be detected in them. The inconspicuous *Sphaceloma* stage was clearly discerned on a few leaf spots of the specimen of August 13. That of August 12, appears to be more or less sterile. What apparently are fructifications of the fungus are developing on some of the stem cankers.

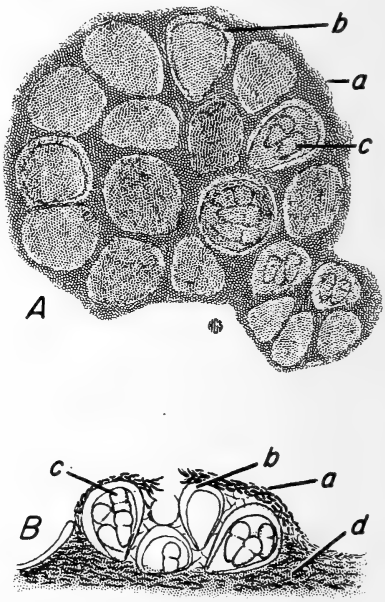

FIG. 2.—*A*, Viewed from above, thin ascoma of the *Elsinoë* on practically transparent leaf-spot tissue; *a*, dark epithecium; *b*, ascus; *c*, ascospores indistinctly visible; $\times$500. For a similar illustration of another species of *Elsinoë*, cf. Arnaud (*1*, pl. 4, figs. C, D). *B*, Section of a smaller ascoma; *a*, epithecium; *b*, ascus; *c*, ascospores; *d*, leaf-spot tissue; $\times$450. Drawings by Stueler; *A* based on a photomicrograph by Bitancourt and original material; *B* on a photomicrograph by M. A. Jaeger and original material.

[2] Translated into Latin by Edith K. Cash.

[3] These specimens represent a survey for this disease being made by Dr. Jehle in collaboration with one of us (Jenkins).

[4] In citing this specimen in our preliminary report (*4*), through a misunderstanding, we gave "Athens" instead of "Atlanta" as the place of collection. The sentence on page 254, line 11, beginning with "Dr. Miller" should be omitted. Since this paper was written Dr. Miller has collected *Elsinoë* at Athens.

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ENTOMOLOGY.—*A synopsis of the Nearctic species of* Elachiptera *and related genera* (*Diptera, Chloropidae*).[1] Curtis W. Sabrosky, U. S. Bureau of Entomology and Plant Quarantine.

Flies of the genus *Elachiptera* Macquart (*sensu lato*) are common in general collecting, and an up-to-date key for their ready identification should be useful. Certain species, apparently abundant and widely distributed, have in the past been generally identified upon certain gross features, a practice that has concealed the presence of some unnamed species with less apparent characteristics, such as the presence or absence of pollen on the ocellar tubercle.

The frequent appearance of these flies in rearing cages has sometimes caused them to be recorded in the literature as pests of various plants. Available evidence suggests, however, that the larvae probably feed upon decaying organic matter, such as old leaf sheaths, or decaying plant tissue and grass following damage by other insects.

Generic limits are difficult to define, especially when more than one faunal region is considered, in the large group of species that may be referred to as the "*Elachiptera* complex." The flattened arista and the marginal scutellar tubercles, two of the most distinctive features of "typical" *Elachiptera* (*brevipennis, costata,* etc.), are subject to a wide range in development in different species. Whatever the character used, there seems always to be an otherwise characteristic species that is an exception. As for the various genera that have been erected for species of this complex (*Elachiptera* Macquart, *Melanochaeta* Bezzi, *Doliomyia* Johannsen, *Crassiseta* Loew, *Eribolus* Becker), the definition of what is a distinct genus, what a subgenus, and what a synonym is extremely difficult. In this paper *Eribolus* is recognized as a distinct genus, and *Crassiseta* and *Doliomyia* are considered as synonyms of *Elachiptera* (*sensu stricto*). *Doliomyia* has a peculiar type of abdomen that might seem to merit separate status for that name, but many species of *Elachiptera* show some lengthening of the basal segment, and in Africa there are several species which nearly match the extreme condition in *D. longiventris* Johannsen.

The status and relationships of *Melanochaeta* need much further study, and its species have not been included here. In recent years it has often been considered a subgenus of *Elachiptera*. One new species, *M. kaw*, is described here because the past confusion with *Monochaetoscinella nigricornis* (Loew) would otherwise leave a common form without a name.

Recognition of the relation of *E.* (*Melanochaeta*) *nigricornis* (Loew) to *Monochaetoscinella* Duda brings the latter name into the *Elachiptera* complex. Its genotype, the Neotropical *M. anonyma* (Williston), has a slender, *Oscinella*-type arista, and its affinities had been supposed to be with *Oscinella*. It is now realized, however, that *nigricornis* (with flattened arista) and *anonyma* (with slender arista) have the same fundamental features of generic significance, and that the development of the arista in the former is only a specific character in that case. Because of other distinctive characteristics, and because the few known species are Neotropical to southern United States, I recognize it here as a genus distinct from *Elachiptera*.

All ratios used in the key and descriptions are based on measurements with an ocular micrometer, and not on estimates.

[1] Received August 18, 1948.

For greater precision in the measures used, the width of the front is defined as the distance between the eyes across the posterior ocelli, the length of the front is the distance from the anterior margin of the front at the midline to an imaginary line between the posterior ocelli, and the basal width of the scutellum is measured between the two lateral points where the disk of the scutellum touches the mesonotum. It is especially important to note the last, for sometimes the sides of the scutellum as they slope downward and outward from the base make the basal width appear greater in proportion to the length than it really is.

Most of the species of this complex will pass to *Crassiseta* in Curran's *The families and genera of North American Diptera* (1934) and to *Elachiptera* in Williston's *Manual* (1908), on the basis of the following characters: Costa extending to the fourth longitudinal vein, hind tibia without a spur, second costal sector longer than the third sector or at least not remarkably abbreviated, and arista flattened and ensiform. The species which will be difficult to place here without comparative study are those with slender, atypical arista. The 1+1 notopleural bristles, erect and cruciate ocellars and post-verticals, and the presence (except in *E. aliena*) of 1 or 2 pairs of outstanding fronto-orbitals (Figs. 5, 6) are other features that will aid in segregating this group.

KEY TO THE NEARCTIC SPECIES OF ELACHIPTERA MACQUART AND RELATED GENERA

1. Frontal triangle subshining or with a leaden-gray luster, the entire surface covered with fine gray tomentum or pollen; mesonotum and scutellum with same habitus as triangle, the former characteristically flattened between the dorsocentral lines on posterior half to two-thirds of notum; scutellum flattened and short, less than 0.7 times as long as broad at base (*Eribolus* Becker) 2

   Triangle entirely or predominantly smooth and polished, sometimes with pollen on and around ocellar tubercle; mesonotum usually polished black, or with three stripes of pollen, occasionally broadly pollinose between and including the dorsocentral lines 4

2. Legs predominantly bright yellow, fore coxa always, fore femur entirely or predominantly, and mid and hind femora basally, yellow; palpus yellow in males, more or less infuscated in females (eastern half of North America) ....
   ....1. *Eribolus longulus* (Loew)

   Legs predominantly black, fore coxa always, and all femora except knees narrowly, black (northern and northwestern)..........3

3. Antenna entirely black, or virtually so; palpus black in both sexes.................
   ....2. *Eribolus sudeticus* Becker

   Antenna in large part yellow to orange, often only the dorsal fourth of third segment black; palpus yellow in both sexes......
   ....3. *Eribolus nearcticus*, n. sp.

4. Scutellum of *Oscinella* type (Fig. 9), short and broadly rounded apically, 0.67–0.8 times as long as width at base, the disk gently convex; marginal scutellar bristles not borne on tubercles, one pair of widely separated apicals and one pair of weak subapicals; mesonotum and scutellum smooth, the piliferous punctures fine and inconspicuous, the regularly convex surfaces never densely and coarsely punctured or rugose........5

   Scutellum not as above, more or less trapezoidal in outline and often apically subtruncate (Figs. 10–12), usually somewhat elongate, typically 0.9–1.25 times the width at base (if as short as 0.75, then the marginal scutellars on distinct tubercles); marginal scutellar bristles borne on more or less distinct tubercles, with somewhat approximated apicals and 2–3 pairs of subapicals; mesonotum and scutellum almost always coarsely punctured, usually so densely that the surface appears strongly rugose, in profile the posterior half of mesonotum and the disk of scutellum obviously flattened (*Elachiptera, sensu stricto*)..............7

5. One pair of long, unusually strong, black, and outstanding fronto-orbital bristles (Fig. 5); cheek divided by a diagonal line into a whitish pollinose anterodorsal and a polished black posteroventral portion (*Monochaetoscinella* Duda)........................6

   Not as above, usually with two pairs of slender, pale fronto-orbitals that are longer than the others in fronto-orbital row (cf. Fig. 6), sometimes with none that are outstanding; cheek not so divided, pollinose along entire lower margin of eye.........
   ....*Melanochaeta* spp.
   (*eunota* Loew, *melampus* Becker, *kaw*, n. sp.

6. Arista slender, pubescent, not at all thickened (Neotropical)..........................
   4. *Monochaetoscinella anonyma* (Williston)

   Arista broadly flattened basally, strongly tapering, densely and evenly long haired, the appearance that of typical *Elachiptera* (as in Fig. 7, but tapering from base to apex) (southeastern United States).............
   ..5. *Monochaetoscinella nigricornis* (Loew)

ELACHIPTERA, SENSU STRICTO

7. Basal segment of abdomen peculiarly elongated and developed as a basal plate occupying, in dorsal view, all but tip of abdomen, its length greater than that of mesonotum and scutellum combined........ 6. *Elachiptera* (*E.*) *longiventris* (Johannsen)
   Abdomen without such an elongated basal plate, the basal segment at most half the length of abdomen....................8
8. Fronto-orbitals hairlike, short and all of approximately the same length, none outstanding; mesonotum densely and finely punctured, with no obvious rows of punctures; arista as in *Gaurax*, slender and sparsely short haired.................. ....7. *Elachiptera* (*E.*) *aliena* Becker
   Two pairs of bristles long and outstanding in fronto-orbital row (Fig. 6); mesonotum less densely punctured, at least median and dorsocentral rows distinct; arista usually thickened and densely pubescent, often flattened and ensiform.................9
9. Pleuron entirely or largely reddish yellow, or entire thorax reddish.................10
   Thorax entirely black..................15
10. Scutellum reddish yellow; mesonotum usually reddish yellow, at most narrowly black at neck.............................11
   Scutellum black; mesonotum at least partly black..............................13
11. Mesonotum almost entirely polished, with only a notopleural spot and a narrow prescutellar band of pollen............... ....8. *Elachiptera* (*E.*) *willistoni*, n. sp.
   Mesonotum with a broad median stripe of fine bright pollen, or entirely pollinose..12
12. Scutellum like *E. costata* (cf. Fig. 12), with two pairs of strong marginal tubercles and a weak, basal third pair; mesonotum apparently pollinose on its entire surface... .9. *Elachiptera* (*E.*) sp. (North Carolina)
   Scutellum like *E. willistoni* (cf. Fig. 10), trapezoidal, apical pair of tubercles weak and subapical scarcely distinguishable; mesonotum with a broad median stripe of fine, bright pollen, between and including the dorsocentral lines..................... 10. *Elachiptera* sp. (District of Columbia)
13. Mesonotum reddish on sides, with a broad median black stripe, gray pollinose; scutellum long conical with three pairs of strong tubercles..11. *Elachiptera* (*E.*) *tau*, n. sp.
   Mesonotum entirely black, only the pleuron reddish yellow......................14
14. Mesonotum typically with three stripes of gray pollen, in median and dorsocentral positions; scutellum as in *E. costata* (cf. Fig. 12), with three pairs of strong marginal tubercles................................ ..13. *Elachiptera* (*E.*) *erythropleura*, n. sp
   Mesonotum polished, without stripes of pollen, and with only a narrow prescutellar band of pollen; scutellum strongly narrowed, three pairs of tubercles close together on distal half, the tubercles less distinct than in *costata* and *erythropleura*.... ....14. *Elachiptera* (*E.*) *angusta*, n. sp.
15. Scutellum flattened and elongate, trapezoidal in outline, with three pairs of long, well-developed scutellar tubercles, the apical tubercles strong, obviously longer than broad (Fig. 12); disk of mesonotum broadly pollinose...12. *Elachiptera* (*E.*) *costata* (Loew)
   Scutellum usually shorter and somewhat rounded apically, sometimes narrowed apically, the 2 or 3 pairs of marginal tubercles distinct but small, each not as long as broad (Fig. 11); mesonotum entirely shining or with three stripes of gray pollen rarely the stripes merged together......16
16. Both frontal triangle and ocellar tubercle smooth and polished, without pollen; disk of mesonotum never with stripes of pollen 17
   Frontal triangle polished; ocellar tubercle distinctly gray pollinose,[2] or if shining, the mesonotum with 2 or 3 stripes of gray pollen...............................20
17. Front obviously longer than broad, length 1.1 times the width at vertex (Fig. 14); mesonotum likewise appearing longer than broad, length actually 1.09–1.1 times its width............................... ....17. *Elachiptera* (*E.*) *angustifrons*, n. sp.
   Front appearing approximately as long as broad, length usually 0.83–0.96 times the width at vertex, occasionally the length and width subequal (Fig. 13); mesonotum appearing nearly square, measuring 0.90–1.04 times as long as broad................18
18. Legs predominantly yellow, including all coxae and femora; fore and hind tibiae black; frontal triangle shorter and with sides less convex than in *nigriceps* and *angustistylum*............................... ...16. *Elachiptera* (*E.*) *pechumani*, n. sp.
   Legs more extensively patterned with black, including distal one-third to two-thirds of mid and hind tibiae; frontal triangle large and occupying most of front (Fig. 13), reaching anterior margin of front, or nearly so, and with strongly convex sides......19
19. Arista broad and flat, ensiform, sides parallel nearly to tip, its width one-half to four-fifths that of cheek (Fig. 7)............ ....15. *Elachiptera* (*E.*) *nigriceps* (Loew)
   Arista narrower, in female two-fifths or less the height of cheek, in male slender and only slightly thickened, in both sexes narrowing from base to tip (Fig. 8)........ .18. *Elachiptera* (*E.*) *angustistylum*, n. sp.
20. Hind femur strongly incrassate, its greatest width 2–2.8 times the diameter of hind tibia; disk of mesonotum with three distinct stripes of gray pollen; frontal triangle

[2] In greasy or rubbed specimens, the shiny appearance may be misleading.

long; arista broad and flat on its entire length. 19. *Elachiptera (E.) formosa* (Loew)
Hind femur not strongly incrassate, its greatest width about 1.5–1.85 times the diameter of hind tibia; at least one other character not as above 21

21. Arista broad and flat for its entire length, sides parallel nearly to apex (cf. Fig. 7), its width equal to at least half the distance between posterior ocelli, usually fully equal to the distance; frontal triangle only three-fourths the length of front; mesonotum with 2 or 3 stripes of gray pollen 22
Arista narrower and tapering from base to apex, not broad and flat as above, its width midway only subequal to a single posterior ocellus 23

22. Ocellar tubercle distinctly bright gray pollinose (widespread, northern United States) .... 20. *Elachiptera (E.) vittata*, n. name (= *E. bilineata* Adams, preoc.)
Ocellar tubercle polished black (California).. ..... 21. *Elachiptera (E.) californica*, n. sp.

23. Frontal triangle long, its apex nearly reaching anterior margin of front; front relatively long, its length 1.0–1.07 times the width at vertex................................ .... 22. *Elachiptera (E.) penita* (Adams)
Frontal triangle shorter, only three-fourths the length of front; front relatively broad, its length only 0.87–0.96 times the width at vertex............................. 24

24. Thorax polished, without pollen except on notopleura and around bases of wings.... ...... 23. *Elachiptera (E.) knowltoni*, n. sp.
Thorax typically with two narrow stripes of gray pollen......................... 25

25. Frontal triangle black, and cheeks and posterior portion of front predominantly brown to blackish, the head appearing dark (Alaska to Colorado).................. ..... 24. *Elachiptera (E.) decipiens* (Loew)
Triangle reddish to brown, and front, face and cheeks bright yellow, the head appearing bright (California, Oregon, Idaho)....... ...... 25. *Elachiptera (E.) flaviceps*, n. sp.

Genus **Eribolus** Becker

Eribolus Becker, Archivum zoologicum **1**: 127. 1910. (Type, *E. sudeticus* Becker, by designation of Enderlein, 1911.)

Becker, followed by Enderlein, Duda, and other workers, recognized this as a distinct genus, based on three European species with a rather uniform habitus of flattened, leaden-gray mesonotum, leaden-gray frontal triangle, and slender, slightly thickened arista. Otherwise, its fundamental characters are the same as in *Elachiptera*, notably the 1 +1 notopleural bristles, ocellar and postvertical bristles erect and cruciate, two pairs of fronto-orbital bristles well developed and standing out over the adjoining orbital hairs, eyes with minute and sparse pubescence, and similar wing venation.

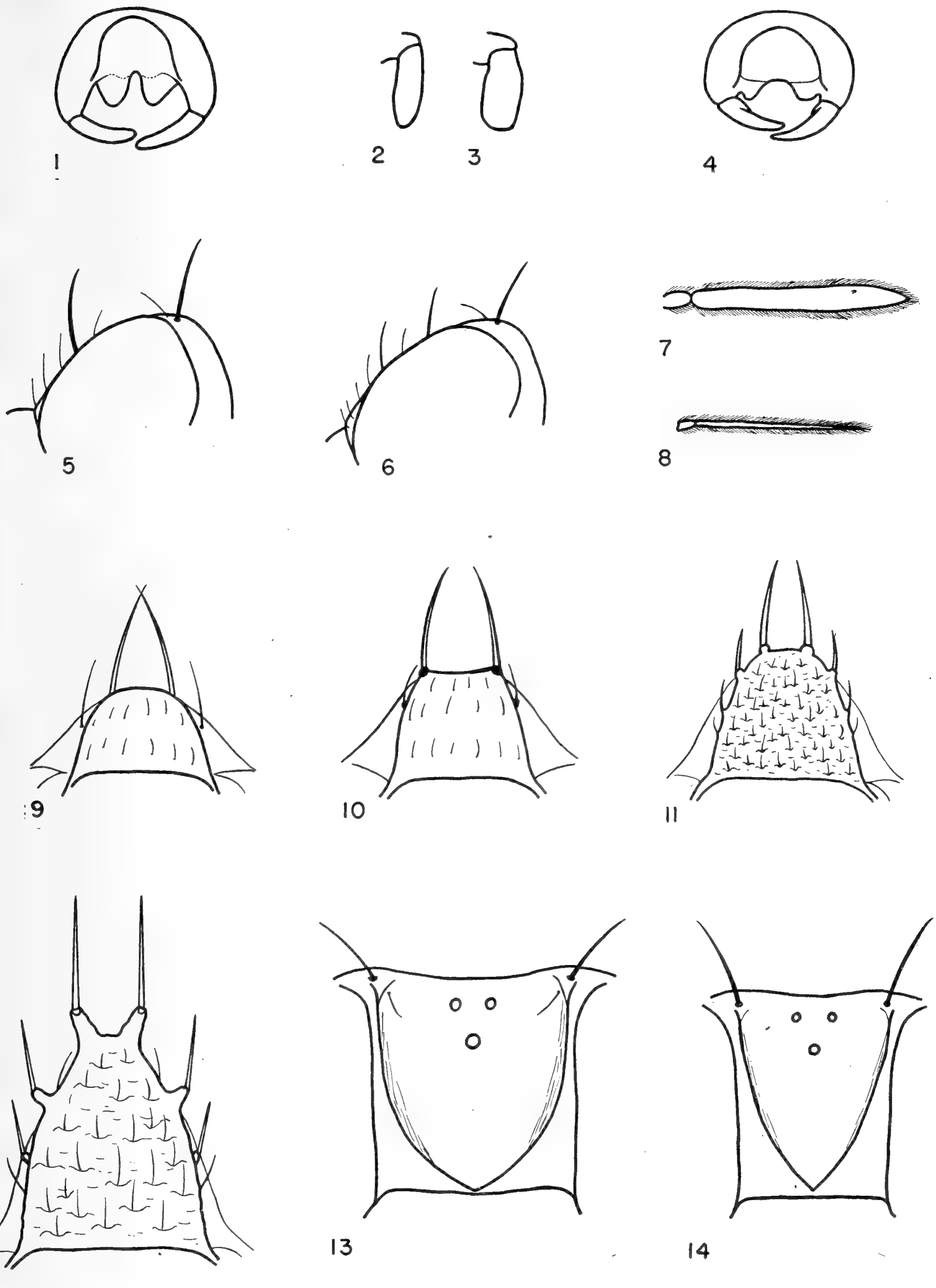
The slightly thickened arista seemed distinct enough in the Palearctic fauna, compared with the broadly flattened, ensiform arista of most of the European species of *Elachiptera*. In North America, however, there is a species which is unquestionably congeneric with *Eribolus* species of Europe, but the arista is somewhat variable, and sometimes, especially in the female sex, it may be definitely (though narrowly) ensiform, as in typical *Elachiptera*. This species, which is quite common in eastern North America, has usually been recorded as *Elachiptera longula* (Loew), or sometimes in combination with the names *Crassiseta* or *Melanochaeta*, but it is placed here in *Eribolus*.

1. **Eribolus longulus** (Loew), n. comb.

Crassiseta longula Loew, Berl. Ent. Zeitschr. **7**: 34. 1863. (Centuria III, No. 64.) (District of Columbia.)
Melanochaeta longula (Loew) Becker, Ann. Mus. Nat. Hung. **10**: 83. 1912.
Melanochaeta intermedia Becker, *ibid.* **10**: 83. 1912. (Pennsylvania.) New synonymy (from holotype in Melander Collection).

The typically bright yellow legs will distinguish this form from either *sudeticus* or *nearcticus*. A few northern and northwestern specimens have been seen in which the areas of infuscation on the mid and hind femora are somewhat more extensive than usual, and even the fore femur may be dusky on the distal half, but the fore coxa and the bases of all femora are always characteristically yellow. The male genitalia are easily distinguished from either of the dark-legged species by the widely spaced cerci (Fig. 4), which are separated from each other by a distance greater than the width of either. The genital forceps, in side view, are narrower than those of *nearcticus*, and are proportioned approximately like those of *sudeticus*, being about four times as long as broad (cf. Fig. 2).

The species is one of the most common and widely distributed chloropids east of the Rocky Mountains. Numerous records are available from Ontario, Quebec, the District of Columbia, and 28 states: Arkansas, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio,



FIGS. 1–4.—Male genitalia of *Eribolus:* 1, *E. sudeticus,* posterior aspect; 2, *E. sudeticus,* side view of forceps; 3, *E. nearcticus,* side view of forceps; 4, *E. longulus,* posterior aspect. FIGS. 5, 6.—Profile of upper half of the head of *Monochaetoscinella nigricornis* (5) and *Elachiptera nigriceps* (6). FIGS. 7, 8.—Side view of arista of *Elachiptera nigriceps* (7) and *E. angustistylum* (8). FIGS. 9–12.—Outline of dorsal aspect of scutellum of *M. nigricornis* (9), *Elachiptera willistoni* (10), *E. nigriceps* (11), and *E. costata* (12). FIGS. 13, 14.—Front and frontal triangle of *E. nigriceps* (13) and *E. angustifrons* (14). Drawings of *willistoni* and *angustifrons* from holotypes, *angustistylum* from female paratopotype. *nearcticus* from male paratopotype, others from determined material.

Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Virginia, Wisconsin, and Wyoming.

2. **Eribolus sudeticus** Becker

Eribolus sudeticus Becker, Archivum zoologicum **1**: 127, 138. 1910. (Europe.)
Oscinella planicollis Becker, Ann. Mus. Nat. Hung. **10**: 114. 1912. (Idaho.) New synonymy.

From Duda's detailed redescription, and from European material available for comparison, I accept *sudeticus* as a Holarctic species. The male genitalia (Fig. 1) are distinct from those of *longulus* or *nearcticus* in the nearness of the cerci, which are separated from each other by a space only one-third the width of the base of a cercus. Each genital forceps in side view is relatively narrow (Fig. 2), about three and one-half times as long as broad and obviously narrower than in *nearcticus*, the other dark-legged species.

The synonymy of *planicollis* had already been noted by Malloch and accepted by Aldrich (Aldrich Card Catalogue), but it does not appear to have been published. I have seen the type, and concur in the conclusion as to its status.

Distribution: Northern, especially northwestern. Numerous specimens have been seen from 12 states (California, Colorado, Idaho, Michigan, Minnesota, Montana, North Dakota, South Dakota, Utah, Washington, Wisconsin, Wyoming), from six Canadian provinces (Alberta, British Columbia, Manitoba, Northwest Territory, Ontario, Quebec), and from Alaska (Fairbanks, Matanuska, Healy).

3. **Eribolus nearcticus,** n. sp.

Near *Eribolus sudeticus,* with black coxae and femora, but the antenna largely yellow to orange and the palpus yellow in both sexes.

Male, female.—Head predominantly black, anterior third of front and basal segments and lower two-thirds to three-fourths of the third segment of antenna yellow to orange, palpus bright yellow in both sexes; frontal triangle slightly shorter than in *longulus*, only 0.78–0.85 times the length of front; the two pairs of well developed fronto-orbital bristles distinctly longer than the adjoining hairs, but relatively short and inconspicuous compared with species of *Elachiptera;* arista pubescent, thickened at base and slightly thickened the rest of its length, but not at all flattened.

Thorax black, the entire dorsum, metanotum, and upper half of the pleuron thickly covered with dully shining, lead-gray pollen. Abdomen brown, only sparsely covered with gray pollen and thus rather shining. Legs with all coxae and femora, except knees narrowly, black, the tibiae and tarsi yellow, in dark specimens the distal tarsal segments infuscated and the hind tibia with a median brown band. Wing venation as in *longulus.* Halter lemon yellow.

Male genitalia intermediate between those of *sudeticus* and *longulus* (Figs. 1 and 4), the cerci separated from each other by a space approximately the width of one cercus; genital forceps broad and paddle-shaped, only 2.3 times as long as broad (Fig. 3).

Length, 1.5–2.5 mm.

Type.—Male, U.S.N.M. no. 58861.

Holotype male, and allotype, near Bottineau, Turtle Mountains, N. Dak., June 21, 1918 (J. M. Aldrich) [U.S.N.M.]. Paratypes: 8 (6 ♂♂, 2 ♀♀), same data as type; 1 ♀, New Ulm, Minn., May 30, 1916 (Aldrich); 1 ♂, Buckeye, Wash., June 21, 1930 (Aldrich); 5 ♂♂, Fairbanks, Alaska, July 1–3, 1921 (Aldrich); 1 ♀, Treesbank, Manitoba, August 27, 1915 (N. Criddle); 2 (♂, ♀), Aweme, Manitoba, September 4, 1916 (N. Criddle); 1 ♂, Toronto, Ontario, October 6, 1891 (Wm. Brodie) [U.S.N.M.]; 2 ♂♂, East Lansing, Mich., May 28, 1940 and April 29, 1942 (C. W. Sabrosky); 1 ♂, Ramsey County, Minn., September 14, 1925 (Sam Kepperley) [Sabrosky Coll.].

The new species is distinguished from *longulus* and from the Holarctic *sudeticus* as outlined in the key. Of the two other species known from Europe, *hungaricus* Becker has an unusually short frontal triangle (usually about half the length of the front) and black palpi in both sexes, and both *hungaricus* and *slesvicensis* Becker have the anterior basal cell more or less broadened. I have seen no material of the latter species, which is apparently similar to *nearcticus* in most respects, but the series of *hungaricus* sent me some years ago by Dr. Duda shows clearly the distinctly broadened cell. Inasmuch as *slesvicensis* was described as having the same type of cell as *hungaricus*, and our American form does not have this type of cell, I accept the latter as a distinct species, even though only that one difference can be stated at the mo-

ment. All three species occurring in North America have the basal cell elongate and narrow, not at all broadened.

Genus **Monochaetoscinella** Duda

Monochaetoscinella Duda, Folia Zool. Hydrobiol. **2**: 107. 1930. (Type, *Oscinis anonyma* Williston, by designation of Duda, 1931.)

The genus *Monochaetoscinella* was segregated from *Oscinella* particularly on the basis of the single pair of long, strong fronto-orbital bristles (Fig. 5). Because the hitherto known species have a slender arista (*anonyma*, *nigripes* Duda, *zernyi* Duda), it has been considered that they are related to *Oscinella*. However, recognition of the fundamental relationship of *Elachiptera nigricornis* (Loew) to *anonyma* and the others, and the flattened, typically *Elachiptera*-like arista of *nigricornis*, now seem to place the genus *Monochaetoscinella* in proper perspective in the *Elachiptera* complex.

The generic characters, other than the single pair of strong fronto-orbitals, are like those of *Elachiptera:* eye distinctly pubescent; ocellar and postvertical bristles erect and cruciate, the former short and weak, the latter long and strong, like the outer verticals; inner verticals weak and hairlike; notopleural bristles 1+1; scutellum short and broadly rounded, as in the subgenus *Melanochaeta* and the genus *Oscinella*, only three-fourths as long as width at base, with one apical and one subapical pair of bristles, the former long, strong, and widely separated, the latter weak and hairlike, neither on tubercles.

In both *anonyma* and *nigricornis*, the cheek is divided into two distinct areas by a slight ridge or line running from the postero-ventral angle of the eye to the vibrissal angle. The anterodorsal area, between the vibrissa and the eye, is whitish pollinose; the posteroventral area is black, smooth and highly polished.

4. **Monochaetoscinella anonyma** (Williston)

Oscinis anonyma Williston, Trans. Ent. Soc. London for 1896; 423. (St. Vincent, West Indies.)
Monochaetoscinella anonyma (Williston) Duda, Folia Zool. Hydrobiol. **2**: 107. 1930.

This species is Neotropical, but it is included here for comparison with *nigricornis* because it is the genotype of *Monochaetoscinella* and also because it is known to occur in Bermuda, and at Key West, Fla., and Tampico, Mexico, and may be expected to be found, at least occasionally, in southern Texas and southern Florida.

The frontal triangle and thorax are predominantly shining and highly polished black, but the ocellar tubercle and scutellum are pollinose and there is a narrow prescutellar band of pollen. The legs are predominantly deep yellow, including all coxae and femora, the fore tibia and fore tarsus are black, and mid and hind tibiae and tarsi are predominantly yellow but may be slightly infuscated.

The species is apparently quite common, for there are a number of published records from Puerto Rico, Bolivia, Peru, Brazil, Costa Rica, Panama, and the Canal Zone, and I have seen numerous examples from Puerto Rico, Cuba, Jamaica, Mexico, Guatemala, Panama, Bolivia, Brazil, and Bermuda. This is probably the species recorded as *Oscinis umbrosa* Loew by C. W. Johnson (1913) in a paper on the Diptera of Bermuda (Ann. Ent. Soc. Amer. **6**: 443–452. 1913).

5. **Monochaetoscinella nigricornis** (Loew), n. comb.

Crassiseta nigricornis Loew, Berl. Ent. Zeitschr. **7**: 34. 1863. (Centuria III, No. 65.) (Louisiana.)
Melanochaeta nigricornis (Lw.) Becker, Ann. Mus. Nat. Hung. **10**: 83. 1912.

This species agrees with the description given for *anonyma*, but differs mainly by its flattened and densely haired, *Elachiptera*-like arista. The present writer and other dipterists have erred in identifying *nigricornis* as a wide-ranging species of eastern United States. On the contrary, careful reexamination of the material shows that two species have been confused by close superficial similarity, and that true *nigricornis* is in reality distinctly a species of southeastern United States, and belongs in the genus *Monochaetoscinella*. The other species belongs in *Melanochaeta* and is described below.

Distribution: Southeastern United States. I have seen material of typical *nigricornis* from Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas. The northernmost records that I have are Raleigh, N. C., Knoxville and Nashville, Tenn., and Fayetteville, Ark.

Melanochaeta kaw, n. sp.

Crassiseta (*Melanochaeta*) *nigricornis* Loew, in part, of Sabrosky, Trans. Amer. Ent. Soc. **61**: 246. 1935.

Shining black species with bright yellow legs, resembling *Oscinella umbrosa* (Loew) except for the flattened and long-haired arista, and differing from the superficially similar *Monochaetoscinella anonyma* as noted in the key.

Male, female.—Head, including antenna and palpus, black, the cheek and anterior half of front paler, brown to dark reddish; thorax entirely black; abdomen brown; legs, including all coxae, bright yellow, at most the distal segment or two of each tarsus browned; halter pale lemon yellow to whitish yellow; wing hyaline, lightly tinted with brown.

Eye short pubescent; front at the vertex one and one-half times the width of an eye and 0.40–0.45 times the width of the head, but appearing relatively narrow because the length of the front is slightly greater than the width; frontal triangle smooth and polished, large and occupying most of front, the basal corners nearly touching the eyes at the vertex and the apex reaching the anterior margin of front; cheek narrow, almost linear, dull and finely pollinose; third antennal segment reniform, 1.7 times as broad as long; arista rather broadly flattened basally but narrowing to apex, the entire length densely covered with long hairs whose length is subequal to the greatest width of the flattened portion, the total effect as seen under low magnification being that of an arista broadly flattened clear to the apex.

Thorax smooth and polished, only the scutellum subshining and covered with gray pollen: piliferous punctures on mesonotum fine and inconspicuous, rather sparse.

Second costal sector of wing 1.3 times the length of third sector: third vein gently curved forward apically, the third and fourth veins diverging slightly: fore crossvein at the middle of the discal cell.

Length, 1.5–1.75 mm.

Type.—Male, U.S.N.M. no. 58870.

Holotype male and allotype, Manhattan, Kans. (C. W. Sabrosky), the type collected June 9, 1934, the allotype September 20, 1933. Types deposited in the U. S. National Museum. Paratypes: 4 (2♂♂, 2♀♀), Manhattan, Kans., October 4, 1933, May 21, 26, and June 26, 1934 (C. W. Sabrosky); 6 (4♂♂, 2♀♀), Manhattan, Kans., August 29 and September 15, 1930, June 1 and 4, 1932 (D. A. Wilbur); 2♀♀, State Lake, Ottawa County, Kans., June 24, 1934 (C. W. Sabrosky); 1♂, Falls Church, Va., June 16 (N. Banks) [Sabrosky Coll.]: 2♀♀, Chesapeake Beach, Md., August 19 and May 30, 1919 (J. M. Aldrich); 1♀, Gatlinburg, Tenn., 5600 ft., July 2, 1947 (R. H. Whittaker); 2♀♀, Plano, Tex., June 1907 (E. S. Tucker, determined as *Elachiptera nigricornis*) [U.S.N.M.]; 1♀, Cheboygan County, Mich., July 18, 1940 (R. I. Sailer) [Kansas Univ. Coll.].

The species is named for an Indian tribe which formerly lived along the Kansas River.

Genus **Elachiptera** Macquart

Elachiptera Macquart, Histoire naturelle des insectes: Diptères **2:** 621. 1835. (Type, *Chlorops brevipennis* Meigen, by original designation and monotypy.)

6. **Elachiptera (E.) longiventris** (Johannsen)

Melanochaeta (*Doliomyia*) *longiventris* Johannsen, Can. Ent. **56:** 89. 1924. (New York.)

The peculiar abdominal structure will separate this species from any other chloropid in North America. In most respects, it is somewhat intermediate between *Elachiptera* and *Eribolus*, but favoring the former. As noted in the introduction, I regard the subgenus *Doliomyia*, proposed for *longiventris*, as a synonym of typical *Elachiptera*, rather than of *Melanochaeta* as Johannsen placed it.

The bristles of the head are greatly reduced, as in *E. aliena*, the ocellars, postverticals and fronto-orbitals being minute and scarcely distinguishable from hairs.

The species is rare in collections. Aside from the three original specimens, all from Ithaca, N. Y., I know of only one other example, a female, College Station, Tex., February 1891 (Webster), labeled "from wheat" [U.S.N.M.]. From this, it may be inferred that the species ranges throughout eastern United States, though rarely collected.

7. **Elachiptera (E.) aliena** Becker

Elachiptera aliena Becker, Ann. Mus. Nat. Hung. **10:** 81. 1912. (Massachusetts.)

Despite its decidedly atypical arista, this species unquestionably belongs in the genus *Elachiptera*, from the general body structure, wing venation, and chaetotaxy. The bristles are reduced in size, however, and thus they do not stand out as strongly as in typical species. The short ocellars and postverticals are convergent

to the tips instead of cruciate, and the usually distinct two pairs of fronto-orbitals are distinguished under relatively high magnification only by being slightly thicker than neighboring fronto-orbital hairs.

The ocellar tubercle is gray pollinose. The humeri are polished black, and under low power the disk of the mesonotum also appears shining and without pollen, though under high power there are sparse, minute flecks of gray pollen on the anterior half. The legs are predominantly yellow, marked with black on the distal half of the mid and hind femora and median third to half of the mid and hind tibiae in the male, and on the distal two-thirds of the corresponding femora and virtually all the corresponding tibiae in the female.

Despite its generally atypical habitus, it is probably best associated with the *nigriceps* group.

The species does not appear to be very common. Relatively few specimens have been seen, though a number of localities are represented. Records are available from nine northeastern states, Illinois, Indiana, Maryland, Michigan, Missouri, New York, Ohio, South Dakota, and Virginia, and from the Province of Ontario. Western record: Custer, S. Dak., July 15, 1924 (F. M. Hull) [South Dakota State College Coll.].

8. **Elachiptera (Elachiptera) willistoni,** n. sp.
(= *E. flavida* and *E. attenuata* of United States records)

Reddish yellow species, only the ocellar tubercle, a divaricate spot on the occiput, dorsal margin of the third antennal segment, and arista, black or dark brown; fore tibia and fore tarsus brown, and apices of other tarsi slightly infuscated.

Front moderately broad, twice the width of an eye and half the width of the head; frontal triangle smooth and polished, both triangle and ocellar tubercle without a trace of pollen, the triangle nearly touching the eyes at the vertex and the apex reaching the anterior margin of the front, the sides slightly convex; in profile the long axis of eye slightly diagonal; width of cheek 0.15–0.2 times the height of the head, commonly 0.17; arista broadly flattened for its entire length, sides parallel nearly to apex.

Thorax slender, narrower than the width of the head and 1.2 times as long as broad, shining and polished except for the sparsely pollinose scutellum, a narrow prescutellar band of pollen, and a little pollen along the lower margin of the notopleuron; bristles long and strong, including 1+1 notopleural, 1 postalar, 1 posterior dorsocentral, and 1 apical scutellar, the humeral and 1 subapical scutellar weak and little longer than hairs; scutellum trapezoidal, 0.8 times as long as broad at base, the apical bristles widely separated at the apical angles (Fig. 10).

Wing venation as usual in the genus; second costal sector slightly longer than the third; third vein nearly straight, third and fourth veins diverging from the base, fore crossvein opposite or only slightly beyond the middle of the discal cell.

Length, 2 mm.

Type.—Male, U.S.N.M. no. 58862.

Holotype male, and allotype, Orlando, Fla., February 9, 1918 (G. G. Ainslie). In the collection of the U. S. National Museum. Paratypes: Florida: 19 (6 ♂♂, 13 ♀♀), Orlando, February 7–19, 1918 (G. G. Ainslie); 1 ♀, Gainesville, February 23, 1918 (G. G. Ainslie); 1 ♂, Paradise Key, February 23, 1919 (Schwarz and Barber); 1 ♂, Orlando, April 30, 1908 (Russell), "bred from onion" (det. Coquillett as *E. flavida*); 2 (♂, ♀), Lake Worth, and 1 ♂, Biscayne Bay (Mrs. Slosson) (det. Coquillett as *E. flavida*) [U.S.N.M.].

Texas: 1 ♂, Santa Maria, April 1, 1908 (McMillan), "bred from celery" (det. Coquillett as *E. flavida*); 8 (1 ♂, 7 ♀♀), Brownsville (E. C. Greene) (det. Malloch as *Crassiseta flavida*); 1 ♂, Brownsville, November 20, 1939 [U.S.N.M.]; 1 ♂, Hidalgo County, August 2, 1928 (R. H. Beamer) [Kansas Univ. Coll.].

Elachiptera willistoni is very close to several Neotropical species with all reddish body color. The specimens from the southern United States have in the past been determined either as *E. flavida* (Williston) or *E. attenuata* Adams, but the former has a slender, scarcely thickened arista and the latter has the arista flattened at the base but strongly attenuated distally. Available specimens of *attenuata* also show a slightly narrower cheek than in *willistoni*, the width measuring only 0.097–0.11 times the height of the head.

This is the form which I referred with some doubt to *E. attenuata* in 1938 (Journ. New York Ent. Soc. **46**: 425), based on specimens from Brownsville, Tex., and Everglades and Lakeland, Fla.

9. **Elachiptera (E.)** sp.

1 ♂, Benson, N. C., August 9, 1934 (R. H. Beamer) [Kansas Univ. Coll.].

Apparently a new species, but the only example before me is headless. The species will not be described until additional material makes it possible to state the important head and antennal characters, but it is included here to make the key as complete as possible for the Nearctic species. In addition to the characters listed in the key, the abdomen is strongly rugose, appearing pitted when viewed from behind.

10. **Elachiptera (E.)** sp.

1 ♀, Washington, D. C., August 5 (J. M. Aldrich) [U.S.N.M.].

The example agrees with *E. willistoni* in all particulars except the presence of a broad median stripe of fine, bright gray pollen. Because of the consistency of this character elsewhere in the genus, it is reasonably certain that an undescribed species is involved here. In view of the single difference, however, and the possibility that it might be an aberrant condition in this case, I shall defer naming the species until an adequate series is available. As with the preceding form, it has been included in the key for the sake of completeness.

11. **Elachiptera (E.) tau,** n. sp.

Yellow to orange, with the arista, apex of third antennal segment at base of arista, an ocellar spot, a broad transverse band on the occiput between the eyes, a T-shaped mark covering the anterior fourth of the mesonotum and a broad stripe between the dorsocentral grooves, entire scutellum, metanotum, and the abdomen mesally and laterally, black; thorax and frontal triangle orange, rest of the head yellow, legs pale yellow.

Front approximately as long as broad, the width at the vertex not quite half the width of the head (0.45); frontal triangle and ocellar tubercle entirely polished, without pollen, the base of the triangle only 0.8 times the width of the front, the apex reaching the anterior margin of the front; cheek narrow, only 0.14 times the height of an eye; eye large, long axis nearly vertical; arista broadly flattened, the sides parallel nearly to the tip.

Mesonotum gray pollinose on the entire surface, though sparsely so in the intra-alar positions; scutellum even more strongly developed than in *costata* (cf. Fig. 12), elongate conical, 1.25 times as long as broad at base, with three pairs of strong marginal tubercles, the apical pair twice as long as broad at base, and closely approximated, separated by the width of the base of one tubercle.

Abdomen rugose, as described for *Elachiptera* sp. from North Carolina.

Veins yellow: second costal sector 1.16 times the third sector; third vein nearly straight, third and fourth slightly divergent from their bases; fore crossvein beyond the middle of the discal cell, as 15:10.

Length, 2.25 mm.

Holotype.—Female, Benton, Ky., June 30, 1939 (R. H. Beamer). Type in the Snow Collection, University of Kansas.

Besides the distinctive color pattern, this species has the longest scutellum and strongest scutellar tubercles of any American species of the genus.

Elachiptera punctulata Becker

Elachiptera nigroscutellata Becker, Ann. Mus. Nat. Hung. **10**: 80. 1912.

E. punctulata Becker (=*nigroscutellata* Becker, 1912, preoc.), *ibid.* **10**: 645. 1912.

Becker described the species from a single specimen in the Winthem Collection in Vienna, said to be from North America. I have seen the type, and it bears only a small square of dark blue paper and a label, "Coll. Winthem." It is unlike anything that I have seen in thousands of American specimens, the black scutellum being short and broadly rounded with two pairs of long, fingerlike, yellow tubercles arising from the lower margin of the scutellum. The cheeks are linear. In these characters it is like the Ethiopian *Cyrtomomyia* Becker, and it is close to the genotype, *C. pulchra* Becker. I believe that *punctulata* was listed erroneously as North American, and that it is more probably of African origin. It was included in my key to the reddish species of *Elachiptera* of the Western Hemisphere (Journ. New York Ent. Soc. **46**: 421. 1938), but at that time I had not studied the African fauna and did not recognize the true affinities of the species. If it should ever be discovered as a rare and aberrant American species, it will run in the present key to *E. tau*, from which it can easily be separated by the form of the scutellum and scutellar tubercles.

Recognition of the status of *punctulata* is especially important because of the discovery of the new American species with black scutellum and predominantly reddish thorax (*E. tau*). The latter is a typical *Elachiptera*, and is related to *costata* and *erythropleura*, but from the generalized description of *punctulata* one might easily have confused the two.

12. **Elachiptera (E.) costata** (Loew)

Crassiseta costata Loew, Berl. Ent. Zeitschr. **7**: 33. 1863. (Centuria III, No. 62.) (District of Columbia.)

The name *costata* is here definitely restricted to what has always been regarded as the "typical form," that with entirely black thorax. The so-called "variety" with reddish pleura is found to consist of two unnamed species, a relatively common one here described as *erythropleura*, and a less frequently collected form which I have called *angusta*.

Loew knew the form with red pleura, but he regarded such specimens as immature individuals of *costata*. The type series of *costata*, in the Museum of Comparative Zoology, contains one female with black pleura and a male and female with reddish pleura; the first female is hereby selected as lectotype of *Crassiseta costata* Loew.

The typical form of *costata* is further distinguished from *erythropleura* by having the disk of the mesonotum broadly pollinose, only the sides narrowly without pollen and shining. In no case have I found the pollen divided into stripes as in *erythropleura*, except of course in badly rubbed specimens which may appear striped because of pollen remaining in the dorsocentral depressions. The strong scutellar tubercles (Fig. 12) are characteristic of *costata*, *erythropleura*, and *tau*, besides a species left unnamed for the present.

Distribution: Common and widely distributed throughout eastern North America, and west to Arizona and Idaho. Specimens have been determined from 28 states, the District of Columbia, and five Canadian provinces: Arizona, Arkansas, Colorado, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio Oklahoma, South Dakota, Texas, Utah, Virginia, Washington; Alberta, Manitoba, Ontario, Quebec, Saskatchewan.

13. **Elachiptera (E.) erythropleura**, n. sp.

Elachiptera costata var. "a" Becker, Ann. Mus. Nat. Hung. **10**: 78. 1912.

Crassiseta costata var. Sabrosky, Trans. Amer. Ent. Soc. **61**: 245. 1935.

Like *costata*, especially in the form of the scutellum, but the pleuron reddish yellow, and the gray pollen on the mesonotum typically in three stripes, on the median and dorsocentral lines.

Male, female.—Head predominantly yellow, only the occiput, frontal triangle except for apex and basal corners, broadly flattened arista, and third antennal segment narrowly at base of arista, black; cheek narrow, one-fifth to one-sixth the height of an eye and one and one-half times the breadth of the arista: front broad, its length only 0.9 times its width at the vertex; frontal triangle large, occupying almost the entire front, the apex attaining the anterior margin of the front and the sides convex; both triangle and ocellar tubercle smooth and polished, without trace of pollen.

Mesonotum and scutellum black; pleuron predominantly reddish yellow, only the propleuron and metapleuron black; prosternum yellow; mesonotum chiefly shining, typically with three stripes of bright gray pollen on the median (acrostichal) and dorsocentral lines; scutellum as in *costata* (cf. Fig. 12), slightly longer than broad (1.05–1.2 times), with three pairs of marginal tubercles, the apical pair strongest, and each of the latter one and one-half times as long as broad at base. Abdomen shining brown to black.

Legs yellow, typically the fore tibia with a narrow and hind tibia with a broad median brown band, fore tarsus and the apical segment of mid and hind tarsi more or less browned.

Wing clear, veins brown, second costal sector nearly one and one-half times the third sector, third and fourth longitudinal veins parallel, fore crossvein joining the discal cell slightly beyond the middle. Halter pale yellow.

Length, 2–2.25 mm.

Type.—Male, U.S.N.M. no. 58863.

Holotype, male, and allotype, East Lansing, Mich., May 25, 1937 (C. W. Sabrosky). Type and allotype deposited in the U. S. National Museum. Paratypes, 152 specimens (61 ♂♂, 91 ♀♀). COLORADO: 1 ♀, Holly, September 6, 1938 (D. E. Hardy) [Kans. Univ.]. DISTRICT OF COLUMBIA: 3 (1 ♂, 2 ♀♀), Washington, April 8,

1945 (M. T. James) [James Coll.]; 6 (4♂♂, 2♀♀), Washington, August 14, 1906, July 11, May 1, 1922, and August 5 [U.S.N.M.]. GEORGIA: 1♂, Prattsburg, July 25, 1930 (P. W. Oman) [Sabrosky Coll.]; 1♀, Perry, March 17, 1945 (P. W. Fattig) [U.S.N.M.]. ILLINOIS: 19 (11♂♂, 8♀♀), Algonquin, Carlinville, Carbondale, Centerville, Dubois, Forest City, Freeport, Golconda, Grand Tower, Muncie, Urbana, and White Heath, various dates, April 3-November 11 [Illinois Nat. Hist. Survey and U.S.N.M.]. INDIANA: 1♀, Vincennes, May 9 (Aldrich); 27 (11♂♂, 16♀♀), Lafayette, April 12–October 22 (Aldrich) [U.S.N.M.]. IOWA: 1♂, Jefferson County, May 18, 1934 (H. Knutson); 1♀, Henry County, May 20, 1935 [Sabrosky Coll.]. KANSAS: 1♂, Lawrence (Aldrich) [U.S.N.M.]; 2♀♀, Manhattan, April 2 and October 8, 1932 (Sabrosky) [Sabrosky Coll.]. MARYLAND: 17 (8♂♂, 9♀♀), Cabin John, Glen Echo, Riverdale, and Plummers Island, April 28-October 21 (Shannon, McAtee, Malloch) [U.S.N.M.]. MASSACHUSETTS: 2♀♀, Beverly, September 10, 1870 (Burgess); 1♀, Cambridge, April 27, 1870 [U.S.N.M.]. MICHIGAN: 4 (3♂♂, 1♀), Detroit, April 18, 1938, and May 11, 1941 (G. Steyskal); 1♀, Lapeer, August 5, 1936 (Steyskal) [Steyskal Coll.]; 1♀, Battle Creek (Aldrich) [U.S.N.M.]; 6 (5♂♂, 1♀), East Lansing, April 28–June 4 (Sabrosky); 2 (♂, ♀), Lapeer, May 30, 1937 (Sabrosky); 1♂, Albion, May 16, 1936 (Sabrosky) [Sabrosky Coll.]. MISSOURI: 1♂, Atherton, September 18, 1915 (Aldrich) [U.S.N.M.]. NEW JERSEY: 1♀, New Brunswick, July 20 [Rutgers Univ. Coll.]. NORTH CAROLINA: 6 (1♂, 5♀♀), Raleigh, June 9–17, 1942 (C. S. Brimley); 1♀, Wilmington, March 7, 1939 (Harris and Wray) [North Carolina Dept. Agr. Coll.]. OHIO: 1♀, Columbus, July 9, 1886 (Wm. B. Alwood) [U.S.N.M.]; 7 (2♂♂, 5♀♀), Summit County, June 24–September 1 (L. J. Lipovsky) [Kansas Univ. Coll.]. PENNSYLVANIA; 1♀, Germantown, May 2, 1909 (Harbeck); 2♀♀, Philadelphia, April 25, 1897 (G. M. Greene) [U.S.N.M.]. SOUTH DAKOTA: 4 (1♂, 3♀♀), Elk Point, September 29, 1915 [U.S.N.M.]. TENNESSEE: 1♀, Knoxville, March 30, 1917 (Aldrich); 1♀, Union City, (G. I. Reeves); 1♀, Reelfoot Lake, April 14, 1944 [U.S.N.M.]; 8 (4♂♂, 4♀♀), Clarksville, July 1–15, 1939 (D. E. & A. T. Hardy, J. D. Beamer) [Kansas Univ. Coll.]. VIRGINIA: 1♀, Falls Church, May 17 (N. Banks) [Sabrosky Coll.]; 17 (4♂♂, 13♀♀), Rosslyn and Dead Run, Fairfax County, April 21–November 18 (R. C. Shannon) [U.S.N.M.].

I have also seen examples from Minnesota, North Dakota, and Rhode Island, but these are not at present available.

This species has usually been recorded as an unnamed color variety of *costata*, but I am convinced that the different pattern of pollen on the mesonotum and the distinctive pleuron mark it as a separate species. In *costata*, also, the head is much darker, the face and cheeks are usually well infuscated, and the median clypeal plate (anteclypeus of Townsend) is shining black. Loew knew the form with red pleuron when he described *costata*, but he considered such individuals to be immature (cf. discussion under *costata*).

The characteristic color pattern of this and the following species (*angusta*) resembles that of *E. sibirica* (Loew) of Europe and Asia. All three seem to be related, but they are definitely distinct. The European species has the humeri, propleuron and sides of the mesonotum reddish yellow, the ocellar tubercle gray pollinose, and the entire mesonotum gray pollinose except for a small area on the anterior slope just behind the head.

Variation: In a few specimens, the sides of the frontal triangle are margined with red, leaving only the central area black. In such individuals the humeri may also be partly reddish. In pale specimens (possibly somewhat teneral), the legs seem entirely yellow. The three mesonotal stripes of pollen vary in width, but are almost invariably distinct: in only three atypical specimens is the pollen more generally distributed and not clearly trivittate.

14. **Elachiptera (E.) angusta**, n. sp.

Near *E. erythropleura*, but without the stripes of pollen on the mesonotum, with narrower front, and with short, rather inconspicuous scutellar tubercles.

Male, female.—Color, general structure, wing venation, and size as described for *erythropleura*, differing in the following particulars:

Head longer than in *erythropleura*, the front slightly longer than broad (1.1 times), the frontal triangle narrower than in that species and contributing to the obviously longer appearance of the front; apex of the triangle

barely failing to attain the anterior margin of the front; cheek narrower, barely wider than the arista and one-eighth to one-ninth the height of an eye; mesonotum with no trace of pollen in the median and dorsocentral positions, only the notopleuron and a narrow prescutellar band sparsely gray pollinose, as is the scutellum; scutellum strongly narrowed in dorsal aspect, its length and width subequal (0.94–1.1 times), three pairs of scutellar tubercles close together on the distal half, the tubercles obviously smaller than in *costata* and *erythropleura*, the largest tubercle only about as long as broad.

Holotype.—Male, Woods Hole, Mass., September 1922 (A. H. Sturtevant). Allotype, Urbana, Ill., June 21, 1888 (Marten; Accession No. 14, 488; "swept from catalpa"). Paratypes: 2 ♂♂, Woods Hole, Mass., September 1922, and July 5–21, 1922 (both collected by Sturtevant). Holotype and one paratype in the American Museum of Natural History, allotype in the collection of the Illinois Natural History Survey, one paratype in the U. S. National Museum.

From the few available specimens, this species seems to be much less common than *erythropleura,* though the similarity in the distinctively reddish pleuron would undoubtedly have caused it to be recorded along with that species as a color variety of *costata.* Greasy specimens of *erythropleura* will appear to be without pollen and hence might be confused here; if the specimens are not in good condition, one should always check the scutellar tubercles to avoid misidentifications.

15. **Elachiptera (E.) nigriceps** (Loew)

Crassiseta nigriceps Loew, Berl. Ent. Zeitschr. **7:** 33. 1863. (Centuria III, No. 63.) (Pennsylvania.)

Male, female.—Head dark, the face and cheek usually predominantly black; frontal triangle large and broad, the sides convex (Fig. 13), both triangle and ocellar tubercle entirely polished black and without pollen; front broad, the length usually 0.85–0.95, occasionally up to 1.0, times the width at the vertex; palpus bright yellow in male, brown to black in female; arista broad, flat and parallel-sided to the tip (Fig. 7), sword-shaped, one-half to four-fifths as wide as the height of the cheek, slightly narrower in the male than in the female.

Thorax polished black except for inconspicuous gray pollen on the notopleuron and about the base of the wing, with piliferous punctures in slightly irregular rows, about two rows between the median and each dorsocentral row; mesonotum nearly square in appearance, and measuring 0.90–1.04 times as long as broad; scutellum short and broadly rounded, 0.75–0.9 times as long as width at base, with three pairs of minute tubercles bearing the short marginal scutellar bristles (Fig. 11); prosternum black.

Legs predominantly yellow, strongly marked with black, the black areas varying somewhat in extent between the sexes and among individuals of the same sex, but always with a fundamental pattern as follows: Distal third of the mid femur except for the knee, distal one-half to two-thirds of the hind femur, proximal one-half to two-thirds of the hind tibia, a variable distal portion of the fore tibia, fore tarsus, and the distal segment of the mid and hind tarsi. Occasional individuals may be paler, especially if teneral, or darker than the indicated extremes, but the constant presence of some black distally on the mid and hind femur and hind tibia seems to mark this form.

Length, 2.25–2.5 mm.

Very common and widely distributed in eastern North America, with a few specimens known from as far west as Manitoba and Washington. Records are available from the Canadian Provinces of Manitoba, Ontario, and Quebec; from the District of Columbia, and from 27 states (predominantly eastern), as follows: Alabama, Colorado, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, and Wisconsin.

16. **Elachiptera (E.) pechumani,** n. sp.

Male, female.—As described for *E. nigriceps,* but the frontal triangle slightly shorter and its sides less convex, not occupying as much of the front as that of *nigriceps;* front yellowish to orange, and face yellow on sides only, centrally black, the general color of the head brighter than in *nigriceps;* palpi deep yellow to orange in both sexes; all coxae and femora bright yellow, the fore and hind tibiae and fore tarsus black, hind tarsus browned distally. To the eye,

a series of this form appears slightly larger and sturdier than specimens of *nigriceps.*

Type.—Male, U.S.N.M. no. 58864.

Holotype male, and allotype, 6 miles south of Middleport, N. Y., July 3, 1941 (L. L. Pechuman), "larvae breeding in large numbers in the base of the flowers of the wild iris, *Iris versicolor.*" Types and paratypes deposited in the U. S. National Museum through the courtesy of Dr. Pechuman. Paratypes: 39 (21 ♂♂, 18 ♀♀), same data as type [U.S.N.M., Cornell Univ., Pechuman Coll., and Sabrosky Coll.]; 2 ♀♀, 13 miles south of Lapeer, Mich., May 30, 1937 (C. W. Sabrosky); 1 ♂, Eaton Rapids, Mich., May 30, 1942 (Sabrosky) [Sabrosky Coll.]; 1 ♂, Algonquin, Ill., September 19, 1894 [U.S.N.M.].

17. **Elachiptera (E.) angustifrons,** n. sp.

Species somewhat intermediate between *nigriceps* and *costata,* differing from the former in having both frontal triangle and scutellum long and relatively narrow and all femora yellow, and from the latter in lacking pollen on the disk of the mesonotum.

Male, female.—Frontal triangle, occiput, lower margin of cheek, face centrally, and arista black, the rest of the head yellow, front deep yellow to orange, palpi yellow in both sexes; triangle and ocellar tubercle entirely polished black; front obviously longer than broad (Fig. 14), the length 1.1 times the width at vertex, the triangle likewise appearing longer and narrower than in species of the *nigriceps* group; eye distinctly emarginate opposite the lunule; cheek narrow, only 0.15 times the height of an eye; arista broad and flat, parallel-sided nearly to apex, its width almost equal to the height of the cheek.

Thorax as described for *nigriceps,* but obviously narrower, the length 1.09–1.1 times the width; scutellum decidedly longer and narrower than in *nigriceps,* 1.1–1.2 times as long as broad at base, the three pairs of marginal scutellar tubercles slightly longer than those of *nigriceps* but not as long and distinct as in *costata* (cf. Figs. 11, 12). Abdomen dark brown, with a large yellow spot above at the base, the basal segment elongated, occupying nearly half the length of the abdomen.

Legs predominantly bright yellow, the pattern as described for *pechumani.*

Length, 2–2.25 mm.

Type.—Male, U.S.N.M. no. 58865.

Holotype male, and allotype, Orlando, Fla., February 18, 1918 (G. G. Ainslie) [U.S.N.M.]. Paratypes: 5 (3 ♂♂, 2 ♀♀), same data as type; 2 (♂, ♀), Wilmington, N. C., June 29 (C. S. Brimley) [Sabrosky Coll.]; 1 ♀, Paradise Key, Fla., February 21, 1919 (Schwarz and Barber); 2 (♂, ♀), Bertrandville, La., February 12, 1944; 2 ♀♀, Chesapeake Beach, Md., July 27, 1913 (R. C. Shannon); 1 ♂, Near Plummers Island, Md., April 7, 1915 (Shannon); 1 ♀, Cabin John Bridge, Md., April 28, 1912 (Knab and Malloch): 1 ♂, San Antonio, Tex., April 8, 1907 (F. C. Pratt) [U.S.N.M.].

18. **Elachiptera (E.) angustistylum,** n. sp.

Male, female.—As described for typical *nigriceps,* but the arista not as broadly flattened, in the female only two-fifths or less the height of the cheek, in the male slender and only slightly thickened, and in both sexes gradually tapering from base to tip, not parallel-sided as in *nigriceps* (Fig. 8, compared with Fig. 7).

Length, 2–2.25 mm.

Type.—Male, U.S.N.M. no. 58866.

Holotype male, and allotype, Spanish Fork, Utah (D. Elmo Hardy). Types and paratypes deposited in the U. S. National Museum through the courtesy of Dr. Hardy. Paratypes: 8 (1 ♂, 7 ♀♀), same data as type [Kansas Univ. and Sabrosky Coll.]; 1 ♂, Cedar, Utah, July 30, 1929 (G. F. Knowlton); 4 ♀♀, Geneva, Utah, April 28, 1933 (Knowlton), Hyde Park, Utah, June 11, 1938 (D. E. Hardy and G. S. Stains), Wellsville, Utah, May 11, 1939 (Knowlton), and Lakeview, Utah, September 20, 1930 (Knowlton) [Utah State Agr. College Coll. and U.S.N.M.]; 2 ♂♂, Scappoose, Oreg., April 23, 1938 (Schuh and Gray); 1 ♀, St. Helena-Scappoose, May 6, 1938 [Sabrosky Coll.].

Because of the unusually slender arista, not at all flattened, the males may be mistaken for the genus *Oscinella,* until one becomes used to the characteristic habitus of the genus *Elachiptera,* and to the character of the two pairs of well-developed fronto-orbital bristles.

This form is like typical *nigriceps* in all respects but the arista, and because of the relatively small difference might be considered only a subspecies, with a western range. Specific differentiation does not necessarily require large

differences, however, and in the absence of any evidence of subspeciation in the present case, I have regarded it as a distinct species.

THE DECIPIENS GROUP

The "*decipiens* group," which includes the remaining species, comprises a number of closely related forms which are characterized by a *nigriceps*-type of scutellum (Fig. 11: flat, rugulose disk, in dorsal view broadly rounded apically with 2 or 3 pairs of small tubercles), and usually the ocellar tubercle bright gray pollinose and mesonotum with 2 or 3 distinct stripes of gray pollen. In *californica* Sabrosky, the stripes are distinct but the ocellar tubercle is shining, and in *penita* Adams the stripes are absent but the ocellar tubercle is strongly pollinose.

In the Palearctic region, the group is represented by *Elachiptera cornuta* (Fallén) and its "varieties" (five recognized by Duda, the latest reviser). Typical *cornuta* and its "varieties" seem to parallel the forms of the *decipiens* group in North America, and it is possible that some of the European and American forms are the same and should be given the same name. Only material of typical *cornuta* is available to me, however, and while *vittata* (=*bilineata* Adams) is close, the slight differences have led me to continue to recognize the latter as distinct. *Elachiptera decipiens*, which is especially abundant in northwestern North America (Alaska to Colorado), and which might be expected to be a Holarctic species, seems to resemble *E. cornuta* var. *strobli* Corti (1909), but I have no examples of the latter for comparison. If they are the same, it should be noted that the name *decipiens* (1863) has priority by many years, and we are thus justified in any case in using the name *decipiens* here. The race or species which I have called *E. flaviceps* is apparently paralleled in Europe by *cornuta* var. *rufifrons* Duda; again, no material is available for critical comparison.

In view of Duda's classification of apparently parallel forms in Europe as merely "varieties" of one common and widespread species, the question also might well be raised whether the American species of the *decipiens* group are only varieties of one species. In North America, however, (1) the segregates recognized here differ from each other in more than one character, (2) they show reasonable uniformity within the segregate in their significant characters, and (3) the available evidence suggests that the several segregates may have characteristic ranges. It is concluded, therefore, that the American forms are either good species, or at the very least, recognizable geographic races (i.e., subspecies).

In most members of this group, the two dorsocentral stripes of pollen are broad and distinct, but the median or acrostichal stripe is narrow, often tapered posteriorly, and frequently appearing to be absent. In general, in *formosa* the median stripe is relatively broad, in *vittata* it is usually present and evident though narrow, and in *decipiens* it is usually not at all evident and the dorsocentral lines are also narrow. Some intraspecific variation exists in the width of the stripes, however, and the appearance may be further influenced by the condition of the specimens.

19. **Elachiptera (E.) formosa** (Loew)

Crassiseta formosa Loew, Berl. Ent. Zeitschr. **7**: 32. 1863. (Centuria III, No. 61.) (District of Columbia.)

This is one of the rarest species of the genus in North America, judged from the paucity of records. The unique feature of the strongly incrassate hind femur is strikingly distinct. Unfortunately, no published description or key has described it with sufficient exactness to avoid possible confusion with *E. decipiens* or other species in which the hind leg is normally slightly enlarged.

Arista broad and flat as in *vittata;* frontal triangle polished black, but ocellar tubercle and posterior corners of triangle gray pollinose; triangle long, its apex barely failing to reach the anterior margin of the front; cheek narrow, only 0.12 the height of an eye; palpus yellow in both sexes. Thorax black, predominantly shining and polished, the disk of the mesonotum with three distinct stripes of gray pollen, the dorsocentral stripes broad, the median narrower, broadest anteriorly and tapering posteriorly, ending opposite the postalar calli, the prescutellar space between the dorsocentral stripes polished and without pollen; humeral

callus predominantly shining; mesonotal hairs more numerous than in the *nigriceps* and *costata* groups, with 4 or 5 irregular rows of piliferous punctures between the median and each dorsocentral position; mesonotum longer than broad, by over 1.15 times; scutellum gray pollinose, its outline like that of *nigriceps*, moderately short and broadly rounded, 0.9 times as long as broad at base, with three pairs of short and inconspicuous marginal tubercles, the tubercles equidistant from each other. Abdomen with basal segment elongate, longer than the next two combined and nearly half the total length of the abdomen, and yellow with sides narrowly brown; second abdominal segment dorsally chiefly yellow with a median brown spot; remaining segments brown. Fore and middle legs chiefly yellow, the fore tibia distally and fore tarsus dark, hind leg reddish yellow with darker tibia; hind femur markedly incrassate, its greatest width 2.0–2.8 times the diameter of the hind tibia and 1.5 times the greatest width of the fore femur.

I have seen only 10 specimens of true *formosa*, in addition to the two cotype females in the Museum of Comparative Zoology: ♂, North Carolina; ♂, Atlantic Beach, Fla. (Mrs. A. T. Slosson); ♀, Lafayette, Ind., August 8 (J. M. Aldrich) [U.S.N.M.]; ♀, Havana, Ill., May 1, 1912 [Ill. Nat. Hist. Survey]; 4 ♀ ♀, Mount Vernon, Va., February 28, 1915 (W. L. McAtee); 1 ♀, Dyke, Va., May 28, 1915; 1 ♀, North Carolina [Malloch Coll.].

A specimen from Mount Washington, N. H. (Mrs. Slosson) [U.S.N.M.], determined by Coquillett as *formosa*, is actually *E. vittata* Sabrosky. This specimen is undoubtedly the basis for the record published by Mrs. Slosson (Ent. News **7**: 264. 1896) and repeated by Johnson (*List of the Diptera or two-winged flies of New England:* 279. 1925).

20. **Elachiptera (E.) vittata,** n. name

Crassiseta bilineata Adams, Kansas Univ. Sci. Bull. **2**: 453. 1904. (Arizona.)

Elachiptera bilineata (Adams) Becker, Ann. Mus. Nat. Hung. **10**: 79. 1912.

Preoccupied by *Chlorops bilineatus* Bigot (Bull. Soc. Zool. France **16**: 279. 1891), referred to *Elachiptera* by Becker (1908, 1910), as a synonym of *E. bimaculata* (Loew).

This species is characterized by the broad, flat arista, short frontal triangle, gray pollinose ocellar tubercle, 2 or 3 stripes of gray pollen on the mesonotum, and broadly rounded scutellum with 2 or 3 pairs of small marginal tubercles. The legs are predominantly yellow to reddish yellow, with some infuscation on the fore tibia distally, the fore tarsus, hind tibia, and hind femur toward the knee, rarely extensively infuscated. Some variation has been observed in the number of rows of hairs between the median and dorsocentral lines, 1 to 3 rows, and this varies the appearance from relatively sparsely to relatively densely haired.

It is the most widely distributed species of the *decipiens* group, for records are available from New York and New Jersey to California across the northern United States. The northward limits are uncertain, but it is interesting to note that all Alaskan material of the *decipiens* group thus far examined has been only typical *decipiens*.

The holotype, a female from Oak Creek Canyon, Ariz., now in the Snow Collection at the University of Kansas, has been personally examined.

Of all American forms, *vittata* is closest to the European *E. cornuta* (Fallén). I have been unable to satisfy myself that the two are the same species, however, and *vittata* has thus been regarded here as a distinct species.

Distribution: Records are available from Alberta, Manitoba, Saskatchewan, and from 14 states: Arizona, California, Idaho, Maryland, Michigan, Montana, New Hampshire, New Jersey, New York, Nevada, Ohio, Oregon, Utah, and Washington.

21. **Elachiptera (E.) californica,** n. sp.

As characterized in the key, and as described for *E. vittata*, differing from that species only in having the ocellar tubercle polished, not pollinose.

Type.—Male, U.S.N.M. no. 58867.

Holotype, male, Ellery Lake, Tioga Pass, Calif., 9,400 ft., July 3, 1927 (J. M. Aldrich). Allotype, Sequoia National Park, Calif., June 11, 1935 (P. W. Oman), Type and allotype in the U. S. National Museum. Paratypes: 1 ♀, Carmel, Calif., July 8, 1938 (M. Cazier); 2 ♂ ♂, San Jacinto, Calif., July 21, 1929 (R. H. Beamer) [Kansas Univ. and Sabrosky Colls.].

22. **Elachiptera (E.) penita** (Adams)

Crassiseta penita Adams, Journ. New York Ent. Soc. **16**: 152. 1908. (Wisconsin.)

I have seen only one specimen that can be referred here, a female, Falmouth Heights, Mass., August 13, 1924 [Amer. Mus. Nat. Hist.]. It is 3 mm in length, somewhat larger than the other species of *Elachiptera*, and with the following characteristics: Arista narrow, only slightly broadened basally and strongly attenuated from base to apex; frontal triangle long, its apex nearly reaching the anterior margin of the front; ocellar tubercle gray pollinose; front relatively long, not appearing broad and square as in the other species of the group (except *formosa*), by actual measurement the length 1.0–1.07 times the width at the vertex; mesonotum without pollinose stripes, the disk polished black, the humeri, notopleura, supra-alar area, a narrow prescutellar band, and the scutellum, gray pollinose; median and dorsocentral lines and the entire posterior slope of the mesonotum punctured and rugose; scutellum shorter than broad, the length 0.9 times the width at base and appearing subtruncate.

I have not seen Adams's cotypes (two males from Wisconsin), but Dr. Aldrich examined them in the University of Arkansas Collection in 1915. He thought that they were probably *formosa* Loew, but he noted that there were no gray stripes on the dorsum. This fact, with several points mentioned in the original description (large size, large triangle, etc.) makes it reasonably certain that the above specimen represents *penita* Adams. It is not a synonym of *formosa*, but a distinct species.

23. Elachiptera (E.) knowltoni, n. sp.

Male, female.—As described for *E. nigriceps*, except as follows: Head lighter in color, the front, face except for central depression, and lower and anterior margins of cheek, yellow; front broad, the length usually 0.92–0.96 times the width at vertex; frontal triangle shorter than in *nigriceps*, the apex not reaching the anterior margin of the front and sides less convex, obviously occupying less of the front than that of *nigriceps;* triangle polished black, but ocellar tubercle distinctly gray-pollinose; palpus bright yellow in both sexes; arista in both sexes only slightly thickened, short pubescent, not at all flattened, and thus resembling that of *Oscinella;* scutellum short and broad, 0.8–0.87 times as long as broad at base.

Legs usually rather extensively infuscated, all femora and tibiae, except bases and apices, brown to black, fore tarsus black and other tarsi browned distally: in the palest specimen, the mid and hind femora broadly yellow at each end, and the fore femur infuscated only on outer surface.

Length, 2.25–2.5 mm.

Type.—Male, U.S.N.M. no. 58868.

Holotype male, and allotype, Randolph, Utah, September 21, 1938 (G. F. Knowlton and F. C. Harmston). Type and allotype deposited in the U. S. National Museum through the courtesy of Dr. Knowlton. Paratypes: 2 (♂, ♀), same data as type [Utah Agr. College Coll.]; COLORADO: 1 ♀, Electric Lake, La Plata County, June 28–30, 1919, about 8,400 ft. [Amer. Mus. Nat. Hist.]: 1 ♀, Holly, September 6, 1938 (D. E. and A. Hardy) [Kansas Univ. Coll.]: 1 ♀, Monument, August 6, 1938 (M. T. James, Urless Lanham) [James Coll.]. IDAHO: 1 ♂, Kellogg, August 14, 1926, altitude 2,305 ft. (R. W. Haegele) [Univ. of Idaho]. MONTANA: 1 ♂, Drummond, August 11, 1931 (R. H. Beamer) [Kansas Univ. Coll.]. NEVADA: 1 ♀, Austin, August 12, 1940 (R. H. Beamer) [Kansas Univ. Coll.]. UTAH: 1 ♀, Blue Creek, September 2, 1938 (Knowlton and Harmston); 1 ♀, Salina, August 16, 1938 (Knowlton and Harmston); 1 ♀, Lewiston, April 27, 1938 (Knowlton and Hardy); 1 ♂, Juab, April 23, 1935 (Knowlton and C. F. Smith); 1 ♂, Hurricane, August 13, 1938 (Knowlton and Harmston) [Utah Agr. College Coll.]; 1 ♀, Spanish Fork (D. E. Hardy) [U.S.N.M.].

24. Elachiptera (E.) decipiens (Loew)

Oscinis decipiens Loew, Berl. Ent. Zeitschr. **7**: 40. 1863. (Centuria III, No. 76.) (Sitka, Alaska.)

Diagnosis: Arista usually somewhat flattened nearly to the apex, sometimes flattened basally and narrowing on the apical half or three-quarters, but in any case decidedly narrower than in *vittata* (cf. key, couplet 21); frontal triangle short, approximately three-fourths the length of the front; ocellar tubercle gray-pollinose; front appearing short and broad, or nearly square, by actual measurement the length only 0.87–0.95 the width at the vertex; mesonotum typically with two relatively narrow dorsocentral stripes of gray pollen. The species usually has a dark appearance, for the yellow on the head is dark, the posterior portions of the front and cheeks are more or less infuscated, and the legs are usually

rather extensively browned, the femora and tibiae more or less predominantly so with varying extent of reddish yellow at base and apex of each. Alaskan specimens are usually darker than those from localities in the United States and southern Canada.

This is definitely not typical *cornuta* Fallén, for the arista is narrower and the legs darker. Whether it is the same as some of the described "varieties" of *cornuta* remains to be determined. As already pointed out, it seems to be near *cornuta* var. *strobli* Corti (1909), and if they prove to be the same, Loew's name has priority.

The considerable amount of Alaskan material that I have seen in the genus *Elachiptera* has consisted entirely of *decipiens*, except for an occasional specimen of *Eribolus sudeticus*. Other than Alaska, I have seen the species from Alberta, Manitoba, Northwest Territory, and Saskatchewan, and from the States of California, Colorado, Idaho, Oregon, Utah, and Washington.

25. **Elachiptera (E.) flaviceps,** n. sp.

As characterized in the key; near *E. decipiens* but the arista slender, scarcely flattened beyond the basal segment; head with bright appearance, predominantly bright yellow, the triangle reddish to brown; legs typically yellow, with scarcely any infuscation.

Length, 2–2.25 mm.

Type.—Male, U.S.N.M. no. 58869.

Holotype, male, Moscow, Idaho, June 2, 1908 (J. M. Aldrich). Allotype, Smith River, Calif., July 17, 1930 (Aldrich). Type and allotype in the U. S. National Museum. Paratypes: CALIFORNIA: 1 ♂, Del Norte County, May 27 [Deutsch. Ent. Museum, Berlin-Dahlem]; 2 (♂, ♀), Berkeley, June 20, 1947 (A. E. Pritchard); 1 ♂, Eureka, March 6 (H. S. Barber) [U.S.N.M.]. OREGON: 1 ♂, Hood River (Childs); 1 ♂, 5 miles west of Sisters, June 26, 1939 (Gray and Schuh); 1 ♂, Vernonia, April 23, 1938 (Gray and Schuh) [Sabrosky Coll.].

The only specimens that have been seen are from far western United States. It is possible that this is only a southern subspecies of *decipiens*. The relation to *cornuta* var. *rufifrons* Duda of Europe cannot now be determined.

Examples of this species could easily be mistaken for *Oscinella*, and would be so placed in most generic keys. Despite the slender, atypical arista, however, the presence of the usual two pairs of strongly developed fronto-orbital bristles and distinct though small marginal scutellar tubercles links the species unquestionably with *Elachiptera*.

PROCEEDINGS OF THE ACADEMY

MINUTES OF 420TH MEETING OF BOARD OF MANAGERS

The 420th meeting of the Board of Managers, held in the Cosmos Club, September 27, 1948, was called to order at 8:05 p.m. by the President, Dr. FREDERICK D. ROSSINI. Others present were: H. S. RAPPLEYE, N. R. SMITH, J. I. HOFFMAN, M. A. MCCALL, W. L. SCHMITT, F. G. BRICKWEDDE, F. M. DEFANDORF, W. N. FENTON, T. D. STEWART, C. F. W. MUESEBECK, W. W. RUBEY, W. A. DAYTON, M. A. MASON, C. L. GARNER, H. G. DORSEY, C. L. GAZIN, and, by invitation, H. E. MCCOMB, L. V. JUDSON, K. F. HERZFELD, and J. E. GRAF.

The following appointments were announced by the President:

Committee to study question of providing a more effective bond between Academy and affiliated societies: To be identical with Committee on Functions and Policies of the Academy (see Minutes of 417th Meeting of Board).

Committee on encouragement of science talent in the schools of the Washington area: M. A. MASON (chairman), A. T. MCPHERSON, B. D. VAN EVERA, and FRANK THONE.

The President also announced that L. V. BERKNER had been appointed as chairman of the subcommittee for the Engineering Sciences of the Committee on Awards for Scientific Achievement, succeeding the late HARRY DIAMOND.

The chairman of the Committee on Membership, H. E. MCCOMB, presented six nominations, five resident and one nonresident.

The chairman of the Committee on Monographs, Dr. L. V. JUDSON, reported that all galley proof for the monograph on *parasitic cuckoos of Africa* had gone back to the printer, the first quarter of the page proof had been returned, and the second quarter of the page proof was in the hands of the Committee. He announced that printing of the monograph was progressing rapidly and that it would very likely be out this year.

Dr. W. L. SCHMITT reported that publication

of the Red Book, which is now in the hands of the members, had cost more than was estimated at the last report in June and that $3,522.55 of the allowed $3,600 had been spent, leaving only $77.45 for the purchase of additional copies. Dr. Schmitt also reported that two members who had their photographs taken by Hessler for the Red Book called attention to the fact that their pictures were not included in the final publication. The Board voted to have the Academy reimburse those two members $5 each for the cost to them of having their pictures taken. The Board of Managers also expressed its gratitude and thanks to Dr. Schmitt for his work in getting out the directory. Moreover, the Secretary was asked to write a letter to Dr. Gilbert Grosvenor expressing the Academy's appreciation for the map of Washington which was issued as a supplement to the Directory.

The Chairman of the Committee on Science Legislation, John E. Graf, reported that legislation before Congress on the proposed Science Foundation had passed the Senate but did not clear the House before adjournment, and that, owing to the volume of other matters, it was not brought up during the emergency session this past summer. To be presented before the next Congress it must now necessarily be reintroduced as a new bill.

In the absence of Chairman Crittenden of the Committee on Functions and Policies of the Academy, M. A. Mason presented the Committee's report, which is here included as an appendix to these minutes.

The Board accepted the report of the Committee and recommended its publication in the Journal as an appendix to the minutes of the 420th meeting. By separate vote the Board approved the new Article I of the Bylaws (to precede the old Article I, which becomes Article II, and so on) and ordered that the amendment be submitted to a vote of the Academy membership, as required by the Bylaws.

Adoption of the proposed Standing Committee on Policy and Planning, requiring an amendment to the Standing Rules, was referred to the Committee on Bylaws for definition and phrasing preparatory to its incorporation into the Standing Rules.

H. T. Herrick was transferred to the retired list of members, effective December 31, 1948.

The Secretary reported the following deaths:

Ernest C. Andrews, honorary member, formerly of the Geological Survey of New South Wales, on July 1, 1948.

Harry Diamond, of the National Bureau of Standards, on June 21, 1948.

Albert K. Fisher, honorary member, formerly of the U. S. Biological Survey, on June 12, 1948.

Francois E. Matthes, formerly of the U. S. Geological Survey, on June 21, 1948.

Oscar E. Meinzer, formerly of the U. S. Geological Survey, on June 14, 1948.

Harold W. Murray, of the U. S. Coast and Geodetic Survey, on June 15, 1948.

Richard C. Tolman, of the California Institute of Technology, on September 5, 1948.

The Senior Editor, Dr. James I. Hoffman, made a progress report on the matter of securing a new printer for the Journal. The George Banta Publishing Co., because of the volume of other work handled, recently notified the Board of Editors that they would be unable to continue printing the Journal. Dr. Hoffman secured bids from certain other printers, and although his conclusions could not be made definite at this time, it appeared likely that the cost of printing the Journal elsewhere would be approximately 10 percent higher than in the immediate past. He expected to have more complete data and formal bids to present at the next meeting of the Board.

The meeting was adjourned at 10 p.m.

C. Lewis Gazin, *Secretary.*

APPENDIX

REPORT OF SPECIAL COMMITTEE ON FUNCTIONS AND POLICIES OF THE ACADEMY

APPOINTMENT AND SCOPE OF COMMITTEE

This committee was appointed on April 6, 1948, in accordance with authorization given by the Board of Managers at its meeting of March 15, 1948 (Journal **38:** 188. May 15, 1948), "to study the functions of the Academy and to formulate a program that will integrate these functions, including the Journal." This action was taken in accordance with one of the recommendations submitted by a Committee on the Journal and its Improvement, under the chairmanship of Dr. R. J. Seeger (Journal **38:** 80. February 15, 1948). President Rossini indicated also that the committee should formulate an introductory article for the Bylaws setting forth the aims and functions of the Academy.

At the meeting of the Board of Managers on June 7, 1948, the Board authorized the appointment of a Special Committee "to improve the ties and relations binding the Academy and its Affiliated Societies." Since this assignment involves policies and functions of the Academy, President Rossini has made this new com-

mittee identical with the one previously established, and the present report deals with both subjects.

ARTICLE FOR BYLAWS

In the Act of Incorporation of the Academy its purposes are indicated by the following paragraph:

3. That its particular business and objects are the promotion of science, with power:
a. To acquire, hold, and convey real estate and other property and to establish general and special funds.
b. To hold meetings.
c. To publish and distribute documents.
d. To conduct lectures.
e. To conduct, endow, or assist investigation in any department of science.
f. To acquire and maintain a library.
g. And, in general, to transact any business pertinent to an academy of sciences.

The Bylaws, however, are often reproduced without the Act of Incorporation. It seems appropriate therefore to include a statement of purposes in the Bylaws, and the committee suggests the text below as a new Article I. Its adoption would of course require renumbering all present Articles and preferably changing "The Washington Academy of Sciences" in Section 1 of the present Article I to "The Academy."

ARTICLE I.—*Purposes*

SECTION 1.—The purposes of the Washington Academy of Sciences shall be:

(a) To stimulate interest in science, both pure and applied.

(b) To promote the advancement of science and the development of its philosophical aspects, through cooperative action by the affiliated societies and by individuals.

These objectives may be attained by:

1. Publication of a periodical and of occasional scientific monographs;

2. Public lectures of broad general scope and interest;

3. Symposia, both formal and in the form of small informal gatherings;

4. Scientific conferences;

5. Awards of prizes and citations for special merit;

6. Grants of funds for special research projects;

7. Organization of, or assistance in, scientific expeditions;

8. Cooperation with other Academies and scientific organizations.

SPECIFIC ACTIVITIES (OTHER THAN PUBLICATION OF THE JOURNAL)

The committee has reviewed the various reports on activities of the Academy which have been presented during the past decade at meetings of the Academy and of the Board of Managers. It has few novel proposals to advance. In fact it believes that the Academy has done very well and has well justified its existence.

As the body of scientific knowledge has grown more vast and diverse, with corresponding pressure for specialization both among individual workers and among scientific and technical societies, the need for connecting links like the Academy has become greater. This need has been intensified by the changes in personnel and in scientific projects which have taken place in the last decade. In Washington and vicinity, in addition to changes in previously existing institutions, there have grown up several large new research laboratories. The present greatly increased interest of the government and the public in science also makes the time appropriate for active prosecution of the Academy's functions.

Meetings.—In view of the large number of meetings held by scientific and technical groups in Washington, it is recognized that the Academy can not well make any considerable increase in the number of its meetings. It is obviously desirable, however, that the Committee on Meetings give special attention to the possibility of obtaining speakers who will present broad philosophical aspects of science as well as those who represent fields of work cutting across the boundaries of the traditional divisions of science. The organization of symposia with speakers from different but related fields is another possible method, perhaps more generally practicable, for bringing together groups of members whose interests are diverse, and this is recommended.

The holding of more joint meetings with affiliated societies has been urged as a means of developing closer relations between the Academy and those societies. Undoubtedly such meetings serve also to bring the Academy to the attention of members of the societies and thus assist in gaining desirable members for the Academy. The Committee on Meetings should take the initiative in maintaining liaison with the program committees in the societies and in arranging joint meetings when appropriate speakers can be found by either committee concerned.

A problem related to arrangements for meetings is that of furthering the development of

acquaintanceship among members. Even those members who attend the meetings usually see each other infrequently. While not proposing to make a social club out of the Academy, your committee believes that definite efforts should be made to stimulate a greater degree of activity in introductions and revivals of acquaintance following the formal meetings. To facilitate this, means might be devised for tagging members with their names and connections, and the Academy might arrange a meeting of some kind once a year purely for acquaintance sake.

With regard to subjects of meetings, the history of the Academy shows a fairly good distribution over the various fields of science. W. A. DAYTON when chairman of the Committee on Meetings prepared a detailed classification of subjects dealt with from 1923 to 1943, inclusive, a total of 151 meetings. With the addition of 30 held in 1944–47, the distribution into very broad classes as set up by Mr. DAYTON is shown in Table 1.

TABLE 1.—CLASSIFICATION OF SUBJECTS OF ACADEMY MEETINGS

Class of Subject	*Number of Meetings*	*Percentage*
Biological sciences	61	33.7
Economic, historical, and social	8	4.4
Engineering sciences	13	7.2
Physical sciences	68	37.6
Awards, exhibitions, and general	31	17.1
Total	181	100.0

In the very broad class of biological sciences, however, were included 16 meetings, or 8.8 percent of the total, devoted to anthropology, archeology, and ethnology. If this group is deducted, biology filled only 24.9 percent of the meetings.

Another type of meeting which members found most interesting in prewar times was a visit to a research institution or a field trip. Such a program involves much work on the part of the hosts, but it has some compensating advantages for them. There are several laboratories or operating plants in Washington which many members of the Academy would be interested to see and which would probably not be averse to a visit in ordinary times. Just at present there would be some special difficulties, and this kind of meeting is therefore suggested as a desirable feature for some future years.

Publications (*monographs*).—Your committee has noted with interest the careful steps which have been taken toward publication of the monograph on *The parasitic cuckoos of Africa*, by Dr. HERBERT FRIEDMANN, this being the initial venture in a program originally approved in 1939 (JOURNAL **29**: 545–546. December 15, 1939). Caution is obviously necessary in embarking upon such a program involving considerable financial risks, but the committee believes that this is a highly appropriate activity, being one which can both serve a useful purpose for science and enhance the prestige of the Academy. The New York Academy of Sciences has apparently carried on successfully an extensive program of this kind. The Washington area should be a prolific source of specialized monographs of a kind which would not appeal to commercial publishers but which should have a sale sufficient to cover the cost of printing and distribution. From a business point of view it must be recognized that such an undertaking initially depends to a large extent upon voluntary service by members who combine good business judgment with a high degree of altruism, but the committee believes that the Academy has many such members.

Memberships.—The committee believes that the membership of the Academy may well be substantially increased in view of the growing importance of Washington as a scientific center. A considerable part of the increase of 100 in active members permitted by the recent amendment to the Bylaws (JOURNAL **38**: 188–189. May 15, 1948), may appropriately be used to round out the membership in fields and in institutions where there are disproportionately small numbers. No general campaign for new members is proposed, nor should there be any lowering of the scientific qualifications required for membership. The committee recommends, however, that emphasis be placed on taking in young men who have shown ability in original research or other scientific attainment.

The distribution of members among different branches of science is indicated to a considerable extent by the memberships held in affiliated societies as shown in Table 2 herewith, although the data supplied for the 1947–48 Directory appear to be incomplete.

The fields from which new members have been received during the past five years are shown in Table 3.

While there are some apparently significant trends shown in these tables a more important problem is presented by the tabulations of members in different organizations as given in the 1947–48 Directory. In spite of the changes in organization of the Department of Agriculture, the bureaus of that Department have maintained a good representation in the Academy, but four other great research organiza-

Table 2.—Membership of Members of Washington Academy in Affiliated Societies

(As indicated in Directories of the Academy, including both resident and nonresident members)

Affiliated Societies	Number of Memberships *1941*	*1947–48*
Philosophical	105	125
Chemical	102	97
Biological	87	76
Geological	75	74
Botanical	71	76
Engineers	28	26
Entomological	27	33
Helminthological	23	26
Medical	23	17
Bacteriological	22	28
Anthropological	18	20
Foresters	15	13
Electrical Engineers	10	13
Mechanical Engineers	6	11
Radio Engineers	5	9
Military Engineers	4	5
Historical	3	2
Archaeological	1	0
Civil Engineers	0	20
Total	625	671
No society memberships shown	58	225
Members of Academy	640	713

Table 3.—Fields of Work of New Members 1942–47 Classified as in Reports to Annual Meetings

Biological		*Physical*		*Geological*	
Botany	25	Chemistry	24	Geology	10
Entomology	13	Physics	23	Paleontology	5
Zoology	7	Engineering	10	Mineralogy	2
Bacteriology	6	Mathematics	8		
Biology	3	Biochemistry	5	Total	17
Physiology	3	Geophysics	4		
Plant pathology	3	Geochemistry	3	Anthropology	15
Cytology	2	Hydraulics	3	Archeology	1
Ichthyology	2	Astronomy	2		
Genetics	1	Geography	2	Total	16
Medicine	1	Meteorology	2		
Plant physiology	1	Ceramics	1		
Total	67	Total	87		

tions which have grown since 1940 to have hundreds of professional employees are represented in the Academy by one to three members. These are the Naval Research Laboratory, the Naval Ordnance Laboratory, the David Taylor Model Basin, and the Johns Hopkins University Applied Physics Laboratory. As the staffs of these institutions come to consider themselves really part of the Washington scene more of them should be drawn into the Academy.

Another problem which the Committee has considered, but one on which opinions differ, is the question whether the scope of the Academy should be stretched to include men working in the social sciences, particularly economics and statistics. It must be admitted that ideas and methods in these fields, and even more in other branches of sociology, are still in an inchoate state, but considering their growing influence in determining governmental policies and economic activities of the country some members of the committee believe that the Academy should be receptive to "social science." Perhaps a first step should be to devote a meeting of the Academy to some subject in this field for which qualified speakers should not be lacking in Washington.

Public policy and publicity.—One of the aims of the Academy is to get the public, including public officials, to appreciate the importance of scientific work and to give science the place which it should have in our national life. At this time when the National Government is taking so large a part in sustaining and directing scientific research it is especially important that the Congress and high executive officials should have the best possible advice on governmental policies affecting science. The location of the Washington Academy at the National Capital gives it a strategic position both for obtaining information on trends of opinion in Government circles and for supplying information and advice to those who are to determine policies. On the other hand, the fact that a large part of its members are employees of the Government lays the Academy open to suspicion of lobbying for the benefit of its own members.

In view of these conflicting considerations the committee believes that the Academy, while giving serious and active study to governmental policies affecting scientific work, should be conservative in publishing any proposals or recommendations in this field. However, the formation of study groups or committees such as that appointed last year to keep in touch with legislation on science is recommended (see reports in Journal **38**: 79. February 15, 1948; and **38**: 220. June 15, 1948), and it is the opinion of the committee that the Academy should engage more actively in preparation and publication of factual studies and surveys bearing upon public policies affecting science.

Junior Academy of Science.—The committee has considered with much sympathy the proposal for the organization of a Junior Washington Academy of Science or such other related activities as the annual science fair, the science talent search, and general cooperation with secondary schools and colleges in the Washington area to stimulate interest in science among young people. This field of activity certainly has promise of great usefulness, but plans for entering upon it need to be considered with care because a vital element is the availability of

members qualified to carry on the work more or less permanently and able to give the necessary time for it. The situation is well summarized in the report of the annual meeting of January 15, 1948 (JOURNAL **38**: 220–222. June 15, 1948). It may be significant that the report indicates the temporary suspension of the Junior Academy in Maryland for lack of a director.

THE JOURNAL

As a basis for considering the status of the JOURNAL of the Academy and determining the policies to be adopted for the future, it is desirable to review reports on past issues. Recent annual reports of the editors and an examination of the 1948 numbers of the JOURNAL give the following data for the postwar period:

TABLE 4.—PERCENTAGE OF PAGES OF JOURNAL DEVOTED TO VARIOUS FIELDS OF SCIENCE

Subjects	*1945*	*1946*	*1947*	*1948* (6 mos.)
Biological	53.4	41.4	53.8	36.0
Physical	7.1	18.2	8.3	38.8
Anthropological	23.8	26.4	20.1	5.9
Geological	5.4	5.6	2.7	2.7
Other (misc.)	0.8	2.2	4.2	2.7
Obituaries, Proceedings, Notices	8.5	5.3	10.0	12.8
Index	1.0	0.9	0.9	1.0 (assumed)

The distribution so far in 1948 is abnormal because some long papers in physics happened to be included in two of the numbers. A breakdown somewhat more detailed and showing trends in specific subjects over a period of years has been made in Table 5 by listing papers (not *pages*) for the last three 5-year periods.

TABLE 5.—NUMBER OF PAPERS IN VARIOUS FIELDS AS CLASSIFIED IN JOURNAL INDEX

(Abstracts in society proceedings not included; also subjects which averaged less than one paper per year are omitted.)

Subject	*1933–37*	*1938–42*	*1943–47*	*Total*
Anthropology	1	7	7	15
Botany	79	66	50	195
Chemistry	20	18	3	41
Entomology	27	37	55	119
Ethnology (incl. linguistics)	3	1	38	42
General (history, etc.)	7	6	5	18
Geology	23	10	3	36
Ichthyology	2	14	20	36
Ornithology	8	7	13	28
Paleobotany	27	17	4	48
Paleontology	36	30	11	77
Physics	20	11	11	42
Zoology	90	52	55	147

It should be noted that this tabulation exaggerates the preponderance of biological papers because those papers quite uniformly average less than half as long as those in physical sciences. Averages for a number of years are as follows: Biological, 4.5 pages; physical, 10.5; anthropological, 8.0; geological, 5.0; other papers, 8.0. This systematic difference in length of papers in the various fields arises from differences in character of the papers, which in turn arise from the distinct purposes which the JOURNAL serves for the various sciences. In biology it provides a place of quick publication for notes on new or redescribed species and other taxonomic papers; in the physical sciences the papers are usually of broader type, many of them being authoritative and comprehensive surveys or summaries of the status in given fields of science or engineering. Both of these classes are useful, and in publishing them the JOURNAL performs a valuable service. The two classes naturally appeal to different groups of readers; in any journal covering so many diverse fields any one reader must expect to find many articles which are of no interest to him, but this fact does not justify a low rating for the journal.

Nevertheless it should be possible to make the Academy JOURNAL more interesting for the general reader by carrying out the recommendation made by the special Committee on the JOURNAL and Its Improvement that the Editors "be continuously vigilant in seeking papers of general interest, in securing copies of outstanding Academy papers, and in selecting papers from different fields for any particular issue" (JOURNAL **38**: 80. February 15, 1948). A suggestion supplementing this recommendation is that the JOURNAL might obtain more presidential addresses as delivered before affiliated societies.

The Boards of Editors have repeatedly surveyed the situation of the JOURNAL and made recommendations for its improvement. (See, for example, JOURNAL **33**: 113. April 15, 1943; **35**: 234. July 15, 1945; **37**: 441. December 15, 1947; and **38**: 218. June 15, 1948.) The Editors have repeatedly pointed out that only about one-half of the papers published in the JOURNAL are written by members of the Academy. The committee would recommend that good papers be accepted or sought without regard to membership of the authors. In brief, publication of articles in the JOURNAL should be considered as marking possible future members, rather than having membership considered a desirable prerequisite for acceptance of papers.

RELATIONS WITH AFFILIATED SOCIETIES

As a first step toward finding ways "to improve the ties and relations binding the Academy and its affiliated societies" in accordance

with the action of the Board of Managers on June 7, 1948, the Committee has sought advice from the Vice-Presidents who represent the affiliated societies in the Board, and has already received cordial replies from two-thirds of them.

It is especially noteworthy that a majority of the Vice-Presidents replying have suggested more meetings arranged jointly by the Academy and the societies. The records of meetings in the annual reports for the past 16 years show considerable fluctuations in the proportion of joint meetings. Out of an average of about seven meetings per year the number reported as jointly arranged has varied from none to a maximum of five in one year, the average being only a little more than one joint meeting per year. One specific suggestion is that the meeting of the Academy at which the address of a retiring President is delivered be arranged as a joint meeting with the Society which represents the major scientific field of the retiring President.

Several of the Vice-Presidents have also mentioned the desirability of getting announcements of Academy meetings to members of affiliated societies who are not members of the Academy. Possible procedures suggested include purchase of announcement cards by the individual societies and reports to the respective societies by the Vice-Presidents representing them in the Board. The expense involved in the one case, and the long advance notice needed in the other, make it questionable whether either of these plans can be worked effectively.

In fact, this problem of informing diverse groups of the many scientific or technical meetings which might interest them is one which affects other bodies in addition to the Academy. The plan which seems at present to give most promise of solving it is the Academy's joint effort with the District of Columbia Council of Engineering and Architectural Societies to have a weekly calendar of meetings published in the local newspapers. (See Journal **37**: 412. November 15, 1947; **37**: 444. December 15, 1947; and **38**: 255. July 15, 1948.)

In considering relations with affiliated societies the question arises whether there may now be additional societies in Washington which should be affiliated. The Committee is not prepared to make any recommendation on this point, but for reference would direct attention to the careful study of this question made shortly before the war (Journal **30**: 46–47, 448, 534. 1940).

RECOMMENDATIONS

Your Committee believes that establishment of policies and detailed planning for their execution over a period of years should be a responsibility of a continuing group. The general responsibility and authority, of course, rest with the Board of Managers. However, the Board as a whole is a rather large body to deal with details, and the present Committee recommends that the Board consider the establishment of a standing Policy and Planning Committee of six members appointed for overlapping 3-year terms and including members who have had experience on the editorial board of the Journal.

Summarizing other recommendations and suggestions in the preceding text we propose the following:

(1) The text of a new Article I of the By-laws;

(2) Meeting directed toward (a) correlating diverse traditional fields of science or (b) dealing with subjects in a broad way so as to be of general interest;

(3) More meetings arranged in cooperation with affiliated societies, and more adequate advertisement of meetings;

(4) Special attention to promotion of acquaintanceship among members, both of the Academy and of affiliated societies;

(5) Further trial of the plan for special publications;

(6) Expansion of the membership especially to get more adequate representation from new laboratories and with emphasis on attracting promising young men;

(7) Study of public policies and governmental actions affecting scientific work, and publication of factual reports on these subjects;

(8) Promotion of interest in science among young people, as for example, by supporting the establishment of a Junior Academy of Science, provided a sufficient group of members appears likely to take a continuing interest in this undertaking;

(9) Efforts to develop the Journal along lines already recommended by the special committee on that subject; and

(10) Collaboration with all other organizations interested in the promotion of science and its application, even taking a sympathetic attitude toward the development of the so-called "social sciences."

E. C. Crittenden, *Chairman.*
Austin H. Clark
William A. Dayton
Martin A. Mason
Leland W. Parr
F. B. Silsbee

Officers of the Washington Academy of Sciences

President..................FREDERICK D. ROSSINI, National Bureau of Standards
Secretary..................................C. LEWIS GAZIN, U. S. National Museum
Treasurer.........................HOWARD S. RAPPLEYE, Coast and Geodetic Survey
Archivist..............................NATHAN R. SMITH, Plant Industry Station
Custodian and Subscription Manager of Publications..............................
..............................HARALD A. REHDER, U. S. National Museum
Vice-Presidents Representing the Affiliated Societies:
Philosophical Society of Washington.........................WALTER RAMBERG
Anthropological Society of Washington....................T. DALE STEWART
Biological Society of Washington..........................JOHN W. ALDRICH
Chemical Society of Washington..........................CHARLES E. WHITE
Entomological Society of Washington..................C. F. W. MUESEBECK
National Geographic Society..........................ALEXANDER WETMORE
Geological Society of Washington.........................WILLIAM W. RUBEY
Medical Society of the District of Columbia................FREDERICK O. COE
Columbia Historical Society...........................GILBERT GROSVENOR
Botanical Society of Washington..........................RONALD BAMFORD
Washington Section, Society of American Foresters........WILLIAM A. DAYTON
Washington Society of Engineers..........................CLIFFORD A. BETTS
Washington Section, American Institute of Electrical Engineers..............
....FRANCIS B. SILSBEE
Washington Section, American Society of Mechanical Engineers..............
....MARTIN A. MASON
Helminthological Society of Washington...................AUREL O. FOSTER
Washington Branch, Society of American Bacteriologists......LORE A. ROGERS
Washington Post, Society of American Military Engineers. CLEMENT L. GARNER
Washington Section, Institute of Radio Engineers.....HERBERT GROVE DORSEY
Washington Section, American Society of Civil Engineers.....OWEN B. FRENCH
Elected Members of the Board of Managers:
To January 1949....................MAX A. McCALL, WALDO L. SCHMITT
To January 1950....................F. G. BRICKWEDDE, WILLIAM W. DIEHL
To January 1951...............FRANCIS M. DEFANDORF, WILLIAM N. FENTON
Board of Managers...................All the above officers plus the Senior Editor
Board of Editors and Associate Editors..............................[See front cover]
Executive Committee........FREDERICK D. ROSSINI (chairman), WALTER RAMBERG,
..................WALDO L. SCHMITT, HOWARD S. RAPPLEYE, C. LEWIS GAZIN
Committee on Membership..
HAROLD E. McCOMB (chairman), LEWIS W. BUTZ, C. WYTHE COOKE, WILLIAM
.........W. DIEHL, LLOYD D. FELTON, REGINA FLANNERY, GEORGE G. MANOV
Committee on Meetings..............................RAYMOND J. SEEGER (chairman),
......FRANK P. CULLINAN, FRED L. MOHLER, FRANCIS O. RICE, FRANK THONE
Committee on Monographs:
To January 1949...........LEWIS V. JUDSON (chairman), EDWARD A. CHAPIN
To January 1950......................ROLAND W. BROWN, HARALD A. REHDER
To January 1951......................WILLIAM N. FENTON, EMMETT W. PRICE
Committee on Awards for Scientific Achievement (KARL F. HERZFELD, general chairman):
For the Biological Sciences...
C. F. W. MUESEBECK (chairman), HARRY S. BERNTON, CHESTER W. EMMONS, ELMER HIGGINS, MARIO MOLLARI, GOTTHOLD STEINER, L. EDWIN YOCUM
For the Engineering Sciences..
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JOURNAL
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ETHNOLOGY.—*The antiquity of the Northwest coast totem pole.*[1] PHILIP DRUCKER, Bureau of American Ethnology, Smithsonian Institution.

The problem of the antiquity of the so-called "totem pole" on the Northwest coast is not a simple one, and yet it is of importance from several points of view: for interpretations of art history of the area; and for appraisals of interareal relationships as well. Barbeau has in various papers assembled evidence which he interprets as indicating the very recent inception of the complex. Other writers have been influenced by his conclusions: Herskovits, for instance, in a discussion of cultural dynamics in his recently published work, was led by Barbeau's view to cite the Northwest coast totem pole as a particularly neat example of a historically documented product of acculturative influences deriving from European contacts.[2] Likewise, Quimby, in a well-considered appraisal of sources and types of extraneous influences on Northwest coast culture during the period of the maritime fur trade, weakens his position slightly by citing the debatable point of historic period origin of the totem pole as a fact along with the far more certain developments he points out.[3] As far as Quimby's thesis is concerned, this one item is of slight importance; the significant points he himself develops as to varieties of racial types and sources of cultural influence are for the most part beyond dispute. However, because of this dangerous tendency for interpretations to be accepted as proved facts, it seems important to point out available evidence that suggests a conclusion quite different from Barbeau's. The aim of the present paper will be to review critically what information can be assembled on the problem.

Barbeau's views as to the recent (historic) beginnings of the art of carving the totem poles on the northern Northwest coast are pretty well summarized in one of his earlier discussions of the problem:

> The art of carving poles is not really as ancient as is generally believed. Its growth to its present proportions is largely confined to the nineteenth century, that is, after the traders had introduced European tools, the steel ax, the adze, and the curved knife, in large numbers among the natives. The lack of suitable tools, wealth, and leisure in earlier times precluded the existence of elaborate structures. The benefits that accrued from the fur trade, besides, stimulated ambitions and rivalries between the leading families. Their only desire was to outdo the others in wealth and the display of prestige. The totem pole became, after 1830, the fashionable way of showing one's power and crests, while commemorating the dead or decorating the houses. The size of the pole and the beauty of its imagery published abroad the fame of those it represented.[4]

That is really a pretty moderate statement especially if the phrase "its growth to its present proportions" is stressed, for few persons familiar with Northwest coast culture of the historic period would deny that the tall carved poles, with their in-

[1] Published by permission of the Smithsonian Institution. The writer wishes to express his thanks to the director of the Massachusetts Historical Society, Boston, and the director of the Peabody Museum, Salem, Mass., for permission to examine and utilize materials from the invaluable records in the archives under their charge. Received October 12, 1948.

[2] M. J. HERSKOVITS, *Man and his works:* 480–481. New York, 1948.

[3] GEORGE QUIMBY, *Culture contact on the Northwest coast, 1785–1795.* Amer. Anthrop. n. s., **50**: 247–255 (254). 1948.

[4] M. BARBEAU, *Totem poles of the Gitksan, Upper Skeena River, British Columbia.* Nat. Mus. Canada Bull. 61 (Anthropological Ser. no. 12): 12. Ottawa, 1929.

volved, stylized, but powerful motifs, became most abundant after 1830, just as Barbeau says, as one of the results of the breakdown of native social patterns brought about on the one hand by the decimation of population (from disease and from increased efficiency of intergroup warfare due to introduction of firearms) and on the other by the enormous influx of new riches brought about by European trade. We know fairly certainly that the pole complex spread southward to Coast Salish territory during historic times.[5] Yet elsewhere Barbeau indicates that he believes the entire complex of carving poles must have come into being since the "day of the early circumnavigators, that is, after 1778"[6] and points to a possible source of influence in the "Kanakas" (whom he describes in a footnote as "Slaves or serfs from the Sandwich Islands who were used in fairly large numbers by the ancient traders," doing something of an injustice to the adventurous spirit that led many Hawaiians to ship aboard the trading vessels to see something more of the world):

> We may wonder whether the insertion of abalone pearl segments as decoration for wood carvings—and this is a notable feature of many of the finest Haida, Tsimsyan, and Tlingit carvings—is not to be traced to this source, since the large, deep sea, shells themselves, from which they are cut, were imported, so we understand from the south sea in the course of transoceanic trade.[7]

And in another place he states:

> . . . we may draw the attention of the reader to the close similarities existing between the plastic arts of the North West Coast and those of various people around the edges of the Pacific ocean. An instance will suffice here. The early navigators noticed, about 1780–1790, the striking resemblances between the fortresses of the Haidas, the Kwakiutl, and other coast natives, to the *hippah* of the New Zealand natives. The totem poles, *as fairly recently carved and erected* on both sides of the Pacific, offer the same compelling evidence (*See* Plate XXX figures 2–5 [reference is to figures showing Northwest Coast totem poles and Maori carved poles and house entry-posts, the latter reproduced from Best's "The Pa Maori, New Zealand." PD]). The technique for their erection was also identical (*See* Plate XXXI, figures 1, 2) [figures showing strikingly similar methods of raising a tall pole, from Tsimshian and Maori. PD].[8]

There appear to be several flaws in the argued derivation from "Kanaka" sources, to which we shall return later on. More important is the line of reasoning that Barbeau follows in arriving at his conclusions. One of his basic points is that totem poles are not described in the accounts left by early European and American explorers. The other is that while aboriginal tools may have sufficed for the carving of small objects, massive carvings such as those of the totem poles were not practicable until the introduction of iron and steel tools by the maritime traders. The reader is in something of a quandary, in regard to the first point, when he reads the quotations from Bartlett and Fleurieu that Barbeau himself cites, describing tall elaborately carved entry-poles of Haida winter houses in the vicinity of Cloak Bay, seen in 1791.[9] It appears, however, that Barbeau draws a distinction between the detached memorial poles, which are his "totem poles," and carvings which were integral parts of the houses, such as the carved house posts, and the entry or frontal-poles that contained the doorway by means of which one entered the house. We may perhaps grant him the distinction between carved house *posts*, and the much taller memorial and entry-poles, carved with multiple figures, but to separate the memorial or commemorative poles from the entry-poles rather vitiates his argument as to the necessity for iron or steel tools for the carving of the former. While from the functional point of view the two varieties of tall carved poles may have been distinct, they were stylistically alike, and one type in-

[5] H. G. Barnett, *The southern extent of totem pole carving.* Pacific Northwest Quarterly **33**: 379–389. 1942.

[6] M. Barbeau, *Alaska beckons:* 248. Caldwell, Idaho, 1947.

[7] Barbeau, 1929, p. 24. "Kanaka" influence is also stressed in Barbeau's paper *The modern growth of the totem pole on the Northwest coast.* Journ. Washington Acad. Sci. **28**: 385–393. 1938. (Also in Smithsonian Inst. Ann. Rept. for 1939: 491–498. 1940.)

[8] Barbeau, 1929, pp. 26–27.

[9] Op. cit., pp. 16, 17. The Bartlett drawing is in a manuscript in the possession of Col. L. R. Jenkins, Director of the Peabody Museum, Salem. It has been published in E. Snow's *The sea, the ship, and the sailor,* Salem, 1925.

volved no more labor than the other in its execution. It is worth noting that the distribution of the entry-pole, set against the outside of the house with the open mouth of a huge figure forming the doorway, had a rather wide if sporadic distribution (and the sporadicity may be due in part to incompleteness of our information from the early historic period). In addition to its occurrence among the Haida,[10] it is reported by a number of observers among the Central Nootkan Clayoquot: Meares, in 1788, and Haswell and Boit, in 1799, were all impressed by the Clayoquot portal pole in "Wikannannish's" house.[11] Haswell's peculiarly punctuated but graphic description of the Clayoquot village is worth quoting:

> Their Towns are larger and much more numerously inhabited than those of the Sound (i.e., Nootka Sound. PD) they are better bult. And are cleaner their Clumas or carved pillers are more numerous and better exicuted some of these are so large that the Mouth serves as doarway into their houses some of their ridgpoals which are of incredable length and bulk are neatly Fluted others are painted in resemblance of various sorts of beasts and birds we met with resemblences of the Sun both painted and carved the rays shoot from every side of the orb which like our Country Sign painters they pictur with eyes nose and mouth and a round plump face.[12]

In addition to the fact that the memorial poles and the entry-poles must be accounted as essentially the same, technologically, at least, there is the fact that memorial poles themselves are reported from several localities during the 1790's. Barbeau himself quotes a passage from Ingraham's *Journal of the Hope* in which Ingraham relates that he went to see "2 pillars in front of a Haida village . . . about 40 feet in height, carved in a very curious manner, indeed, representing Men, Toads, etc. . . . "[13] There can be little doubt that these were totem poles of the same type as those erected in the middle of the 19th century. Fleurieu refers somewhat vaguely to "monuments in honor of the dead" seen at several Haida villages, but does not make clear whether these are the "mausolea or tombs" he described elsewhere (platforms on top of 10-foot poles, and boxes "wrought with art" supported on four short posts).[14] At Lituya Bay, in 1793, the Malaspina expedition saw, and the artist Tomas de Suria sketched, a huge mortuary carving, very clearly representing a grizzly bear, set up alongside of some elaborately carved mortuary boxes raised on poles.[15] In 1794 there occurred the interesting circumstance of a trading ship captain's assisting a Haida chief in setting up a memorial pole. The captain was Josiah Roberts, of the ship *Jefferson*, out of Boston; the Haida chief was "Cunneah," a well-known personage among the maritime traders of the day, whose village was situated on North Island, on Parry Passage. Howay has summarized the very interesting journal of this voyage, which was kept by Bernard Magee, the first officer.[16] Thanks to the courtesy of the director of the Massachusetts Historical Society, where the original manuscript journal is preserved, I was permitted to read and extract pertinent passages from Magee's account. They run as follows:

> [June 17th, 1794] . . . in the afternoon the Capt. with the Carpenters & some hands in the pinnace went to the village at the request of Cunneah to

[10] Marchand, Bartlett, and others have given us descriptions of tall Haida portal poles, elaborately carved, seen in the early 1790's. These descriptions, which Barbeau (1929) has reproduced in full, make clear that the objects were tall poles, not "posts through which a round mouthlike entrance had been cut," as Barbeau phrases it (1947, p. 235).

[11] Meares, quoted by Barbeau, loc. cit., p. 16; Haswell and Boit in: F. W. HOWAY, *Voyages of the Columbia*, Massachusetts Hist. Soc. Publ. 61, 69 pp. Boston, 1941.

[12] HASWELL, loc. cit.

[13] J. INGRAHAM, quoted in Barbeau, 1939, p. 496.

[14] FLEURIEU, quoted by Barbeau, op. cit., pp. 17–18, 203.

[15] This Suria drawing was noted some years ago by Wagner in a paper on Suria's journal (H. R. WAGNER, *The voyage of Tomas de Suria to the Northwest coast, 1791–1793*, Pacific Hist. Rev. **5**: 234–276. 1936. The drawing appears in a publication of the Museo Naval de Madrid, 1932; it has recently been reproduced by Wolfgang Paalen in a very enlightened article on Northwest coast art published in the magazine DYN (no. 4–5, Mexico, 1943).

[16] F. W. HOWAY, *A Yankee trader on the Northwest coast, 1791–1795*, Washington Hist. Quarterly **21**: 83–94. 1930. Barbeau, 1947, p. 250, apparently refers to this incident when he speaks of "a seaman named Jefferson" who helped the Haidas erect a carved pole.

plane and smooth a monumental pillar of wood—previous to its erection on the morrow—in the evening returned on board . . .

[18th] . . . in the morning I went in the pinnace with the Carpenters and 2 hands to the village took along with us 2 spair topmasts for sheers & sufficient Tackling to set up the pillar—which in the afternoon got in its place—after finishing the necessary requisites for its intended purpose of sepulture of a daughter of Cunneah's—I returned to the ship . . .

On the 19th, Cunneah and his wife invited Captain Roberts and his officers to the village. The captain, the ship's doctor, and the supercargo attended the mortuary potlatch. Cunneah gave each of the officers a sea-otter skin, the dead child's father (Magee seems to have erred in his statement of the relationship made the previous day) likewise made them gifts, and other chiefs followed suit. Cunneah then requested the captain to have the pole painted. This passage with the description of the potlatch has been published verbatim by Howay in his paper on the journal. Some days later, Magee was again sent by the captain to the village:

[July 8th] . . . in the afternoon I went to the village with some hands at the desire of Cunneah in the morning—to raise an image on the monument lately set up—which they cut and carved with a great deal of art—being the representation of some wild anemile—unknown to us—somewhat the resemblance of a tode . . .

Several interesting details may be remarked in this account in addition to the fact of the erection of a mortuary pole, which we may suppose to have been (and as a slightly later journal makes clear definitely *was*) a pole like the famous recent Old Kasaan Bear pole, with the addition of having a small excavation chopped out in the back to contain the dead child's body, Haida-fashion. We note that even in 1794, after some years of contact and trade in the Parry Passage vicinity, where nearly all ships that made the coast put in, the Indians, despite their appreciation of white carpenters' and riggers' superior techniques, had not acquired the manual dexterity to use the European tools, which of course require a completely different set of motor habits. As a matter of fact, ethnographic accounts show that the adz in one or another of its local forms remained in use until the latter part of the nineteenth century. It persisted despite the fact that for close work it is a much more laborious and a much slower implement than the plane and spokeshave. The same persistence of old tool patterns is documented at Nootka Sound, not far to the south, where white contact was even more intense than in Haida territory. Jewitt relates that during his enforced stay at Nootka, 1803 to 1805, the natives continued felling trees with their iron-bladed chisels, although it took several of them two or three days to fell a tree, chipping away around and around it beaver-fashion, that he and Thompson could have laid low in a few hours with their axes. And yet, being a practical people, the Northwest coast natives recognized the advantages of the superior tools it took them so long to get the knack of using.

It should be noted too, in Magee's account, that the initiative in the matter came from Cunneah; Captain Roberts simply had the base pole cut and "planed" and set up as the Haida chief wanted it done. Roberts's aim was clear. All he cared about was cultivating the chief's goodwill, in the hope of being given preference when the latter had furs for trade. The "wild anemile" figure that surmounted the post was carved by native craftsmen; certainly there is no intimation that the ship's carpenters had the least thing to do with it.

We are fortunate in having a description of this same pole from the pen of a more articulate writer than Magee. In 1799, the ship *Eliza*, Captain James Rowan, out of Boston, was trading along the Queen Charlotte Islands. On March 22 of that year, her ship's clerk, whose journal is preserved in the Massachusetts Historical Society archives, went ashore to spend the night at Cunneah's invitation.[17] The journal gives a lively sketch of Haida house-life, as

[17] As Howay has pointed out (in the *Voyages of the Columbia*, p. 96, note 3. 1941), the attribution of this journal to William Sturgis is incorrect. Sturgis was first officer of the *Eliza* on this voyage, and his log is in the same archives, but it is a real deck log—his "Remarks" columns contain almost nothing but winds, sails set, depth of water and type of ground at anchorages, and the like.

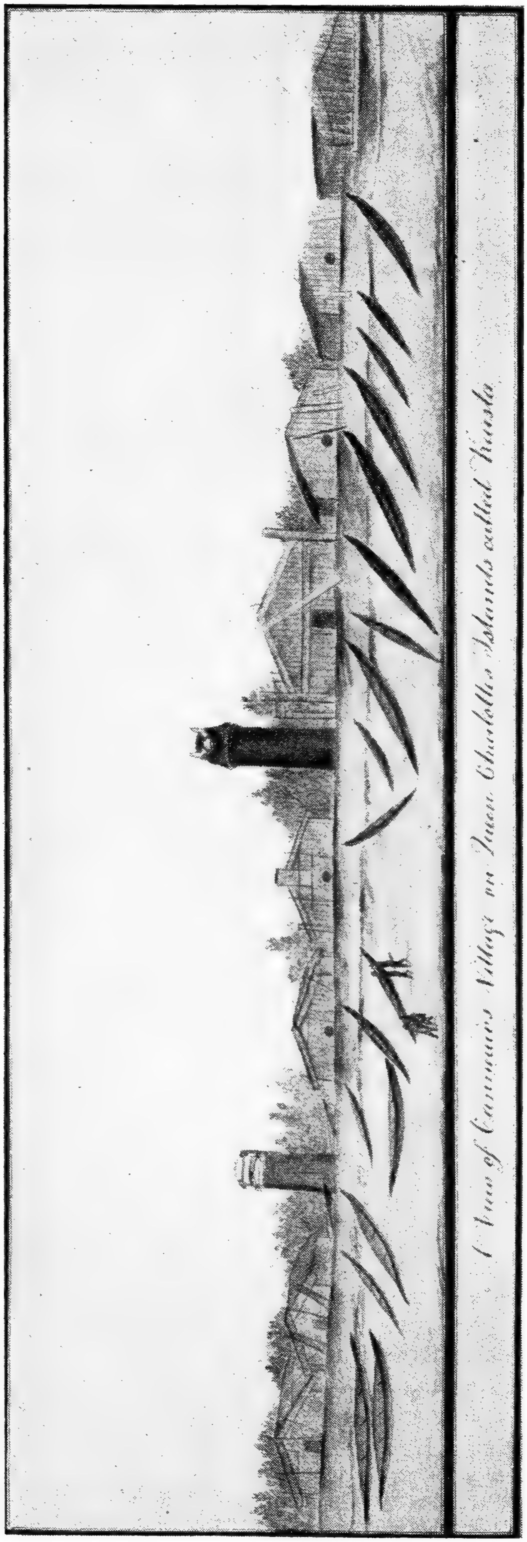


FIG. 1.—View of "Cunneaw's" village, from the journal of the ship *Eliza* (1799). Reproduced through the courtesy of the Massachusetts Historical Society.

witnessed on that occasion, then under the date of March 23, goes on to say:

> In the morning I rose early to examine the village, and take a sketch of it . . . [this sketch s reproduced in Fig. 1 of the present paper. PD] the village consisted of 8 houses of which Cunneaws was the largest, being about 50 feet long, 30 broad and 15 to the rise of the roof. to the peak of it I suppose was about 22 or 3 feet. At the right hand of the village as you go to it were a number of wooden structures raised I suppose over the bodies of their dead chiefs. some were exactly like a gallows, some a solid square piece of timber about 15 feet high on which were carved the figures of men and children. but the only thing I saw which had any idea of proportion, was a Pillar by the side of Cunneaw's house on top of which was a figure intended to represent a bear; the figure and Pillar were both painted red with Ochre. the teeth, eyes, nostrils, and the inside of the ears (which were stuck forward) of the animal were made of mother of Pearl shell; which gave it a very beautiful appearance, in comparison to what North West Sculpture generally has . . .

This pole, consisting of an animal figure surmounting a straight plain shaft, alongside the same chief's house, must have been the one Magee told of, even though he thought the "wild anemile" figure represented a "tode." His remark that it was "carved with a great deal of art" is significant. In other words, the bear figure, which called forth both men's admiration, was a pretty gaudy, not to say garish, item. This fact, together with the utter lack of comment on the other carved poles by most writers (and the very casual mention by the writer of the journal just quoted), suggests that the few data we have on Northwest coast carving from the early historic period are more justly to be attributed to the poor artistic taste of the seafarers than to the nonexistence of the sculptures at that time. A few days before the writing of the above passage, the journal has a description of "Altatsee's village of Tatanee," near Cloak Bay, which, we are informed, "consisted of the large Number of two Houses . . . " Going ashore in the evening, the keeper of the journal spent the night, and then, under the date of March 11, relates:

> I rose at daybreak and having taken a sketch of the two houses, to save the length of description [this sketch unfortunately is missing from the journal. PD], and seen two images that were at a short distance from them which Altatsee told me were intended to represent two Chiefs, that were his relatives (or rather they were his ancestors for they looked as if they were upwards of a hundred years of age) that had been killed in battle . . . (etc.)

In addition to the lack of appreciation of native art, we have so few mentions of carved poles for another very obvious reason. The winter villages, where such poles stood, were situated in sheltered coves with sloping sand or gravel beaches on which canoes were easily landed and launched. These sites are often actually partly drowned alluvial fans. The sailing-ship people sought anchorages in coves and harbors of quite another sort: they needed sheltered but deep water, so that they could pay out plenty of cable and swing with the tides without going aground. Sometimes they moored, of course, usually by a bower anchor and a hawser run from aft to the shore, made fast to a tree, but this was an emergency measure, really, and dangerous because at times the Indians cut the hawsers, either to steal them or with the hope of wrecking the vessel. Actually few people on board, aside from those who deliberately went by boat or canoe for the purpose, ever saw the winter villages. In addition, many of the traders stayed on the coast only through the summer season, and lay to off localities where the summer camps of the natives were, running down to the Hawaiian Islands to winter if they wanted to trade a second season.

However, even from the few accounts mentioned, it seems fairly clear that in the 1790's, when the traders first began to comb the coast, and visited the winter villages, there were not only elaborately carved portal or entry poles in Haida territory (and at Clayoquot), but there were also mortuary and memorial poles standing at the Haida villages and among the northern Tlingit. It seems that such poles were more commonly to one side of the village (among the Haida and at Lituya Bay), rather than directly in front of it, as the later custom developed, but they were being put up, nonetheless. I am not familiar with any journal that describes Tsimshian winter villages of this period. The *Eliza*

appears to have been one of the first trading vessels, if not the first, to trade with the Nisqa up Observatory Inlet, but her people never went up the mouth of the river to the village and have left no description of it.

There is another line of evidence concerning use of memorial poles which may be considered. De Laguna has recently traced use of such features—most of them are, to be sure, less ornate than those of the northern Northwest coast, but many of them involved some carving of simple figures, and/or painting—from as far south as the Columbia River Basin northward along the coast to southwest Alaska and down the coast of northeast Asia.[18] On the basis of such a distribution, the Tlingit-Haida-Tsimshian memorial pole complex (and the intimately related entry-pole pattern) would seem to be but a local intensification and elaboration of what has all the earmarks of a moderately old trait.

To return a moment to the question of "Kanaka" influence on Northwest coast art, it is necessary to consider the route of the English and American traders. After beating their way around Cape Horn they sometimes put in for wood and water at islands off the South American coast. The Americans were a little chary of doing this, the English dared not, for their ships were sure to be confiscated and they themselves interned by the jealous Spanish authorities. Whether they put in there or not, however, they stood for the Hawaiian Islands running before the Southeast Trade Winds, where they were sure of plenty of water, fresh stores, and wood. Many ships that planned to spend several seasons trading on the Coast ran down to the Islands to winter. By and large the traders maintained good relations with the Hawaiians, being very conscious of the latter's numbers and warlike proclivities—besides those natives had no treasures by which the traders might be tempted. The captains soon learned that when they were short a hand or two, replacements could be recruited easily (very early in the trade, a chief's son who wanted to see the world was taken to the Coast, to China, and back to Hawaii, which may have set a precedent), and the Hawaiians seem to have made good hands. We know that several Hawaiians made more than one voyage to the Northwest coast, for at times they acted as interpreters between Indians and whites.[19] Yet there seem to be no records—at least I know of none—of Maori being taken to the Northwest coast. Yet the Maori carved portal poles and carved house fronts are the ones whose similarity to Northwest coast totem poles is pointed out by Barbeau; the Hawaiians, so far as we know, did no such elaborate monumental carving.

The use of abalone-shell inlays is more easily understood as the transfer of the inlay technique from sea-otter teeth and the opercula of a sea snail, which was noted by the earliest voyagers on the Northwest coast,[20] to a new and attractive material. The shells themselves seem to have been imported from California by the Spanish—not from the "South Seas"—they are usually referred to in the accounts as "Monterrey shells."

Barbeau also brings up the question of Russian influence on the Northwest coast at a very early period.[21] That too is a doubtful point. The Russians were in "Alaska" by the middle of the eighteenth century, but the part of Alaska they were in is a long way from the Northwest coast. They were reaping a golden harvest in *southwest* Alaska, and so far as available records go made no attempt to cross the Gulf of Alaska until well along in the 1790's (establishing a short-lived post at Yakutat 1796 and an ill-fated fort near Sitka, in 1799). Native trade along this wide unfriendly reach of coast did occur—as witness the Cross Sound atlatls, Aleut in type carved with Tlingit designs, and the *umiak*, perhaps Chugachmiut in origin, seen at Port Mulgrave by La Perouse,[22] but there is no

[18] F. DE LAGUNA, *The prehistory of northern North America as seen from the Yukon.* Soc. Amer. Arch. Mem. 3 (Suppl. to Amer. Antiquity **12**: no. 3), pp. 90 ff. 1947.

[19] QUIMBY, 1948, refers to a number of cases of Hawaiians who shipped to the coast.

[20] Cf. JAMES COOK, *Voyage to the Pacific Ocean* (etc.) **2**: 327.

[21] BARBEAU, 1929. p. 22.

[22] The atlatls are figured by O. M. DALTON, *Ethnographic collections from the northern coast of North America.* Internat. Archiv für Ethnogr.

evidence that such trade occurred on a scale sufficient to account for the abundance of iron on the Northwest coast as having simply been passed on from the Russian establishment on Kodiak Island. After all, Nootka Sound is many miles and a multitude of hands, in hand to hand exchange, from Kodiak Island, and it was at Nootka that Cook saw iron-bladed tools to the practical exclusion of all other forms. There is no evidence, in short, that the Russian influence on Tlingit and other Northwest coast tribes was of any importance until the very end of the eighteenth century, by which time the natives had learned a smattering of English and had acquired vast quantities of American and British-made trade goods.

Nor can trade from Hudson's Bay Company posts be considered a very likely source. For one thing, in Cook's time, and for some years, the nearest Hudson's Bay post was many days' travel inland, to the east of the Rockies. For another, the types of the iron implements themselves—the heavy-bladed, rapidly tapering daggers (on the northern coasts, at least, double-pointed ones were in vogue at the time of first European visits) and the well-known curved knives—do not appear to have been forms made and traded by Hudson's Bay Company. And finally, if any coureur de bois who had any contact with outlying Hudson's Bay posts had ever crossed the mountains, Mackenzie, who was a practical as well as a bold explorer, would surely have got information that would have saved him many of the painful mistakes he made on his heartbreaking "journey to the Pacific Ocean."

It seems evident, in short, that the source of Northwest coast iron tools can not be attributed either to Russian or to Hudson's Bay Company sources but must have lain in some earlier iron-using contact, from which the precious pieces came along well-established trade channels, dribbling slowly down the length of the coast. One is tempted to suggest some late (A.D.) Siberian "Iron Age" culture as a source, despite present lack of knowledge of the eastward extent of such cultures. Collins has discussed in some detail the most likely source of the iron found in the Punuk horizon of western Eskimo culture; the metal made its appearance at the beginning of that period, more than a thousand years ago.[23] Iron from the same Asiatic source may have been transmitted along a route that eventually brought it to the natives of the Northwest coast in ancient times. That iron from a non-European source was in use in the Alaska Peninsula at the beginning of the historic period is made clear by Steller's remarks concerning the iron knives carried by the natives he saw on the Shumagin Islands in 1741. He states:

> From the distance I observed the nature of the knife very carefully as one of the Americans unsheathed it . . . . It was easy to see that it was of iron, and, besides, that it was not like any European product.[24]

The persistent tradition among Northwest coast natives that their forefathers first obtained iron from timbers containing spikes or bolts or other fittings that drifted up on the beach—presumably timbers of wrecked vessels—has suggested to some writers that this material may have come from junks—Chinese or Japanese—swept from the Asiatic coast by the Japanese Current. The possibility of such craft reaching the Northwest coast periodically, with iron implements aboard, and perhaps survivors of their crews to teach the use of them, can not be dismissed. We have not only the evidence of the Japanese glass net floats, and more recently, mines, that drift ashore in quantities on the outer beaches from the Queen Charlotte Islands to the Oregon, and perhaps northern California coasts, but there is the well-documented incident of the Japanese junk

10: 227–245, pl. 15. 1897. C. H. Read, *Account of a collection* . . . , Journ. Roy. Anthrop. Inst. **21**: 99–108, fig. 3, 1891. A. P. Niblack, The Coast Indians of Southern Alaska . . . , U. S. Nat. Mus. Rept. for 1888, pp. 225–386. 1890. The umiak is described and figured by La Perouse, *Voyage autour le monde* . . . , **1**: 390. Paris, 1797.

[23] Henry B. Collins, Jr., *Archeology of St. Lawrence Island, Alaska.* Smithsonian Misc. Coll. **96**, no. 1, pp. 304–305, 329. 1937.

[24] Steller, *in* F. A. Golder, *Bering's voyages*, Amer. Geogr. Soc. Research Ser. No. 2, **2**: 97. 1922.

wrecked on Cape Flattery with three crewmen still alive.[25] Or perhaps both these possible sources were involved, including the Siberian Iron Age one.

This discussion seems to have gone pretty far afield from its avowed theme of Northwest coast totem poles. Yet all the facts are pertinent. Even if the hypothesis is allowed that the origin of Northwest coast art was intimately linked with the use of metal tools, it is not necessary to assume that these tools, and the beginnings of the art style and even its maximum expression in the great carved poles, must be dated after the period of first European contacts in the closing decades of the eighteenth century. Three separate sets of facts indicate that Northwest coast art, and the carving of totem poles themselves, antedated all European influences in the area. First, not only small objects carved in best Northwest coast style but totem poles themselves were seen by the first Europeans who had the curiosity to go visit the winter villages where such poles might be found, in northern Tlingit country, among the Haida, and in a related form, among the Nootkan Clayoquot. Second, these poles, or at least the poles in their memorial function, seem to represent an elaboration of a burial complex involving use of memorial poles set up by the graves that extended from the Northwestern United States clear around the Pacific rim into northeastern Asia. And finally, even if such carving was dependent on the use of iron (as of course can not be conclusively proved), it seems most probable that the tribes of the Northwest coast obtained their iron from some Asiatic source long before the entry of Europeans or Russians into the North Pacific.

[25] C. M. Drury, *Early American contacts with the Japanese.* Pacific Northwest Quarterly **36**: 319–330. 1945.

However, despite Quimby's statements (1948, p. 247), there are no known records of Japanese reaching the coast during the period of the maritime trade, let alone before. As for timbers with iron in them, however, wrecks of junks seem doubtful possibilities. At least it is my understanding that one of the characteristics of junks, in addition to their bluff lines, shallow keels, and lug sails, is the lack of metal involved in their construction. For iron-bearing timbers the best possibility would seem to be wreckage from the occasional lost "nao de Manila"—the galleons that plied between Manila and Acapulco beginning nearly two centuries before Cook stood in to Nootka Sound.

ARCHEOLOGY.—*Early cultural manifestations exposed by the archeological survey of the Buggs Island Reservoir in southern Virginia and northern North Carolina.*[1]

Carl F. Miller, River Basin Surveys, Bureau of American Ethnology, Smithsonian Institution. (Communicated by Matthew W. Stirling.)

During the months of February through April 1947, three governmental agencies, the Corps of Engineers, the National Park Service, and the Smithsonian Institution conducted an archeological survey of the area to be flooded by the Buggs Island dam. The dam is being constructed 178.7 river miles above the mouth of the Roanoke River in Mecklenburg County, Va., about 20.3 miles downstream from Clarksville, Va., and 18 miles upstream from the Virginia–North Carolina boundary, taking in part of Mecklenburg, Halifax, and Charlotte Counties in Virginia and Warren, Vance, and Granville Counties in North Carolina.

The Roanoke River rises on the eastern slopes of the Appalachian Mountains, flows in a southeasterly direction toward the Atlantic coast, and empties into Albemarle Sound, N. C. The principal tributary, the Dan River, rises in Patrick County, Va., flows into North Carolina, and ultimately returns to Virginia where it enters the Roanoke at Clarksville. A small portion of the drainage basin lies in the rugged terrain of the Allegheny and Blue Ridge Mountains, the remainder is in the Piedmont Plateau. The latter is a rolling to hilly country with elevations ranging from 300 to 900 feet above mean sea level. The river channel varies in width from 100 feet in the upper to about 800 feet in the lower reaches.

Ninety-four sites were listed by the

[1] Received September 2, 1948.

survey, these comprising 34 village sites, 17 camp sites, 41 flint work shops, and 2 historic iron-working sites. In addition, eight other sites were located outside of the reservoir proper, which will be affected by the reservoir action.

The survey shows that most of the inhabitants preferred to settle on the bottom lands usually on ground high enough to afford enough drainage yet close to the river or its tributaries. It is upon the hills away from the streams that the oldest manifestations were found. No mounds were noted within the Basin.

Evidence gathered during the survey points to two main cultural horizons, an extremely early culture characterized by an eastern variant of Folsom, as distinguished from the true Folsom found in the western part of the United States, and accompanying groups, besides a very much later pottery-making group. Evidence of early man is not new, as former workers have noted his remains in Virginia and other parts of the East. Large numbers of points (Fig. 1, *a–d*) attributed to the eastern variant of Folsom have been noted as coming from this particular section of Virginia and North Carolina. The possibility of two Folsom camp sites within the basin makes the area more interesting.

In the interval between the Folsom occupation and the later occupants of the area, it seems that other early groups were present. This evidence occurs in the form of projectile points having characteristic outlines, peculiarities of chipping—readily recognized out of context, and are comparable to a number found in sites in the western part of the United States.

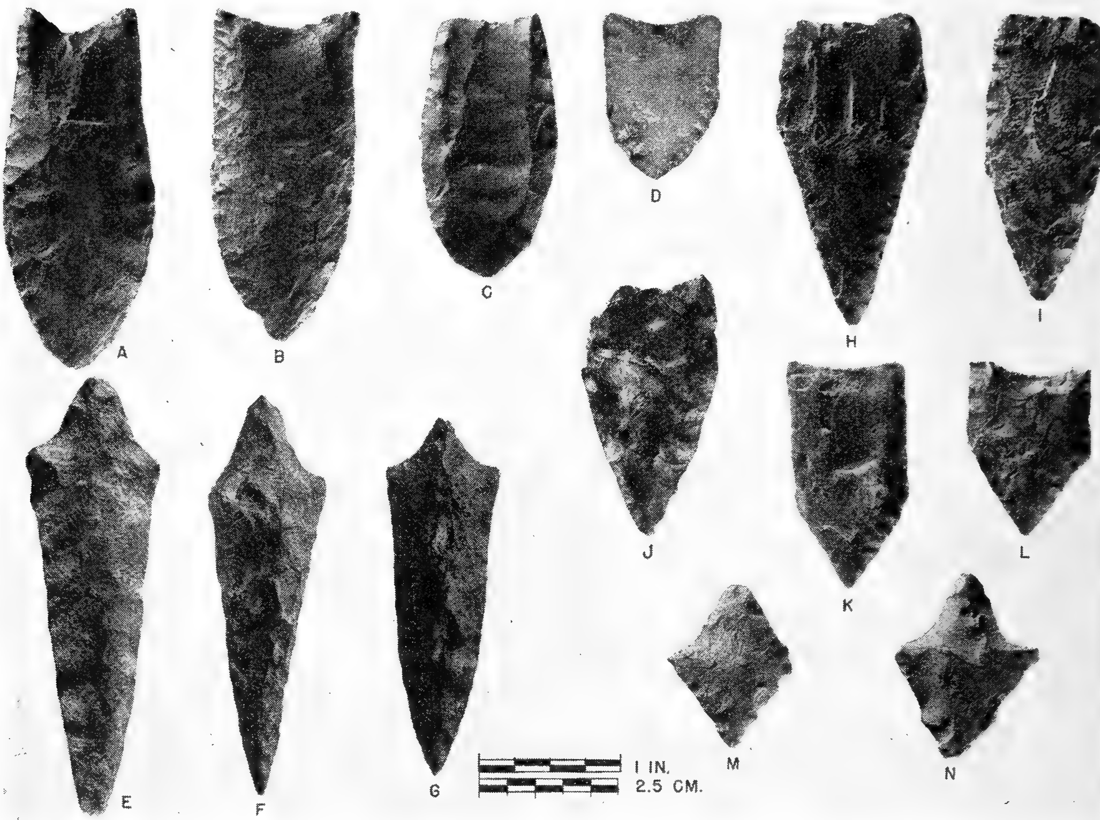


FIG. 1.—Types of early projectile points from the Buggs Island Reservoir: *a–d*, eastern variant of the Folsom; *e–g*, Gypsum Cave; *h–l*, pentagonal; *m, n*, Manzano points.

Harrington[2] in his exploration of the Gypsum Cave in Nevada located a number of points attributed by him to early occupants of the cave and were called Gypsum Cave points. These resemble a number of points, similar in outline and chipping, found in southern Spain and assigned to the Solutrean Period. Points resembling these were recovered from the surface of sites in the Buggs Island basin; the best of these are shown in Fig. 1, *e–g*.

Hibben,[3] while excavating a cave in the Manzano Mountains in New Mexico, found another distinctive type of point which he attributes to early man in that section. Similar points (Fig. 1, *m, n*) were recovered from the surface of a site in the Buggs Island basin. These points resemble those found by Harrington at Gypsum Caves with the exception that the Manzano specimens seem to have considerably more flare and definition of shoulder and apparently can be assigned to the same relative period, that is, later than Folsom. In this case the makers of this type of point came into southern Virginia and northern North Carolina at a time when Folsom points were no longer manufactured and possibly when Folsom man had vacated this section of the country.

Various pentagonal types are found associated with the eastern variant of the Folsom which show fluting and comparable base treatment. These are best illustrated by types *h, i, j, k*, and *l*, of Fig. 1.

Apparently there was a time, after these early occupants, when no settlements were established in the area. At a much later date a possible prepottery group infiltrated and occupied certain sections of Virginia and North Carolina which in turn were followed by pottery-making groups whose culture compares favorably with that of the Watts Bar and Candy Creek Foci of Tennessee.

At the time of the coming of white man a Siouan group is reported to have occupied the Occaneechi Island at the confluence of the Dan and Roanoke Rivers. This site was abandoned before or about 1700 for in 1701 they were reported to be occupying sites in northern North Carolina.

The archeology of this section of the East is practically unknown, and until actual excavation of the various sites has been accomplished and a thorough study of the data obtained, no definite tie-in with known cultures can be made.

[2] Harrington, Mark Raymond, *Gypsum Cave Nevada*. Southwest Museum Papers, no. 8. 1933.

[3] Hibben, Frank C. *Evidences of early occupation in Sandia Cave, New Mexico, and other sites in the Sandia-Manzano region*. Smithsonian Misc. Coll. **99** (23). 1941.

ENTOMOLOGY.—Simulium virgatum *Coquillett and a new related species (Diptera: Simuliidae)*.[1]

Alan Stone, U. S. Bureau of Entomology and Plant Quarantine.

Since considerable confusion exists as to the identity of the simuliid fly *Simulium virgatum* Coquillett, this paper is offered to facilitate determination of the species and to describe a closely related new species that has been confused with it. The species here treated fall into the subgenus *Dyarella* Vargas, Martínez, and Díaz (1946) (type, *Simulium mexicanum* Bellardi), and this paper deals with the only two species of the subgenus now known from the United States. This subgenus may be diagnosed as follows:

Usually rather large species; antenna with 11 segments; anterior veins of wing with both hairs and spines; vein R with or without setae; radial sector not forked; vein Cu_2 curved; postnotum without pilosity; hind basitarsus with a well-developed calcipala; second hind tarsal segment with a distinct pedisulcus; each claw of hind tarsus of female with a subbasal tooth; anterior gonapophyses of female genitalia large, their inner margins subparallel; paraprocts small; dististyle of male genitalia large and somewhat flattened, not more than 3 times as long as wide with no basal process but with lateral margin sinuous.

The species of this subgenus are not known to attack man, but several have been found feeding on horses.

[1] Received October 8, 1948.

The references given in this paper are by no means complete, only those of real significance being listed.

Simulium (Dyarella) virgatum Coquillett

Simulium virgatum Coquillett, Proc. U. S. Nat. Mus. **25**: 97. 1902 (♀, ♂); Dyar and Shannon, Proc. U. S. Nat. Mus. **69**(10): 39, figs. 82, 83, 126, 127, 128. 1927 (♀, ♂); Fairchild, Ann. Ent. Soc. Amer. **33**(4) 718, figs. 5, 7, 32. 1940 (♀, pupa); Stains and Knowlton, Ann. Ent. Soc. Amer. **36**(2): 274, fig. 75. 1943 (♀ only).

Simulium hippovorum Malloch, U. S. Bur. Ent. Tech. Ser. no. 26: 28, pl. 2, fig. 12. 1914 (♀).

Simulium rubicundulum Knab, Insecutor Inscitiae Menstruus **2**(12): 178. 1914 (♀); Vargas, Martínez, and Díaz, Rev. Inst. Salub. y Enferm. Trop. **7**(3): 105, 106, 111, 163, 179, figs. 132, 160. 1946 (♂, larva).

Simulium virgatum chiapense Hoffmann, [Mex.] Univ. Nac. An. Inst. Biol. **1**(4): 293–297, figs. 2, 9. 1930 (♀ pupa).

Simulium mathesoni Vargas, Rev. Inst. Salub. y Enferm. Trop. **4**(4): 360, figs. 39–43. 1943 (♂) (new synonymy).

Simulium virgatum may be distinguished from all of the species now placed in the subgenus *Dyarella* by the following diagnostic characters:

Male: Scutum with stripes, when viewed posteriorly the pale stripes broad and distinct to the prescutellar depression; wing at least 3.5 mm long; all hairs at base of costa dark. Genitalia: Adminiculum (Fig. 3) with a strong median projection from the posterior border nearly half as long as dististyle; lateral angle of adminiculum a rounded rectangle, the space between central process and lateral margin not strongly concave; dististyle (Fig. 5) when flattened with inner margin nearly straight, outer margin distinctly curved; distal spine very small.

Female: Scutum with distinct curved stripes; wing at least 3.5 mm long; hairs at base of costa on dorsal surface dark; tibiae rather broadly orange-brown medially, not mostly dark with a narrow subbasal pale ring. The female is not separable externally from *briceñoi* V.M. & D., or *hinmani* V.M. & D. Genital fork (Fig. 1) with strong inwardly directed tooth from each arm near base as well as a strong outwardly directed projection; handle with swollen knob at end; paraprocts with strong hairs confined to posterior margin.

Pupa: Respiratory filaments (Fig. 9) 8 (6 in two groups of 3, 2 single); dorsum of thorax smooth, not strongly reticulated. Cocoon (Fig. 7) with dorsal aperture surrounded by numerous projections connected distally.

Type data: *Simulium virgatum* Coquillett: 2 ♂♂, 2 ♀♀, Las Vegas Hot Springs, N. Mex. August 4 to 14 (H. S. Barber). U.S.N.M. no. 6183. The male, collected August 4 with the genitalia mounted on a slide and bearing the label "Type" and Coquillett's determination label, is here designated lectotype.

Simulium hippovorum Malloch: One female in ear of horse, head of Río Piedras Verdes, altitude about 7,300 feet, Sierra Madre, Mexico (C. H. T. Townsend). U.S.N.M. no. 15407.

Simulium rubicundulum Knab: Córdoba, Mexico, December 17, 1907, one ♀ (F. Knab); Las Vegas Hot Springs, N. Mex., August 7, one ♀ (H. S. Barber), U.S.N.M. no. 19112 The Córdoba specimen was selected by Dyar and Shannon (1927) as type. The other specimen is presumably one of the females of the type series of *virgatum*, only the specimen of *virgatum* here selected as lectotype having received a type label.

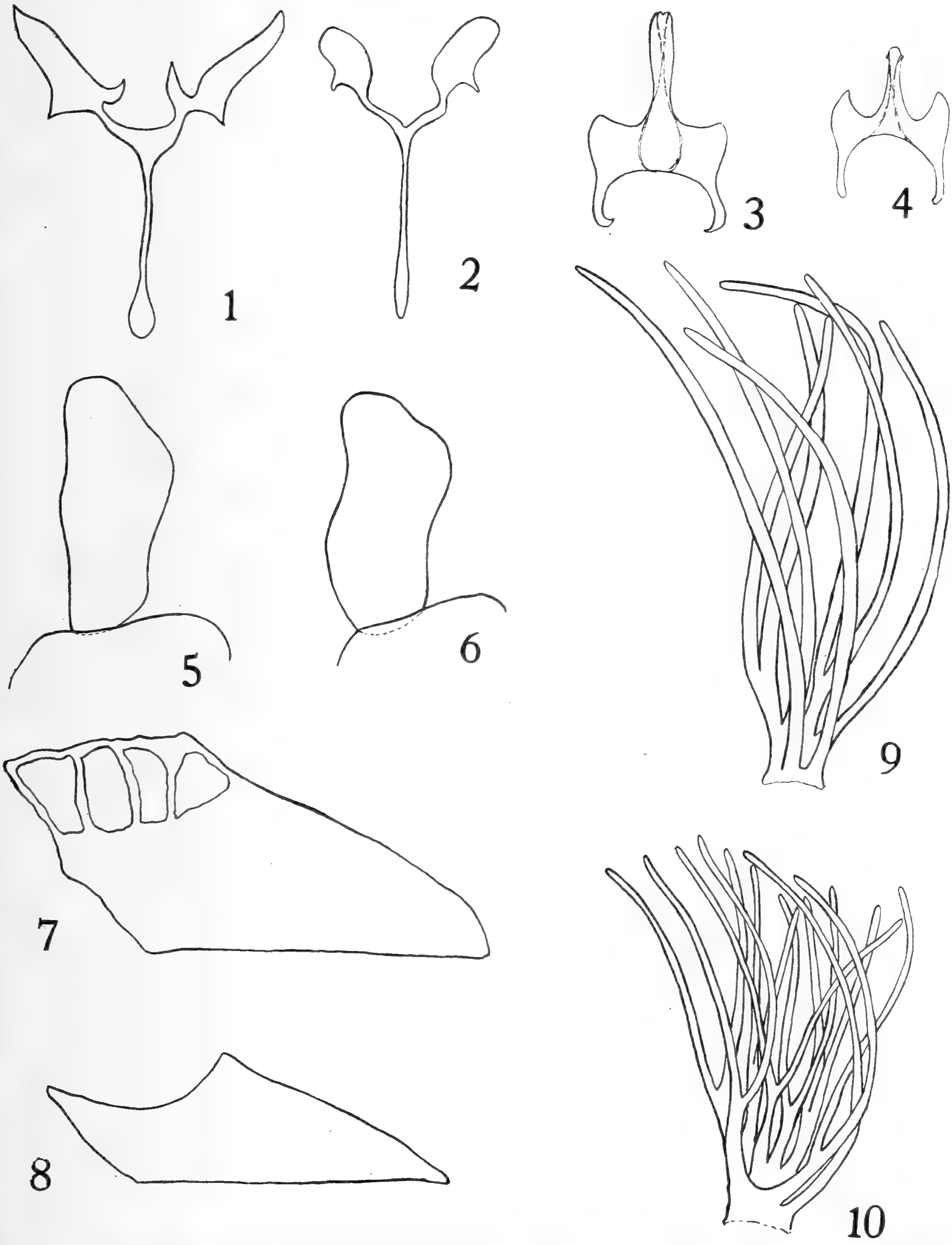
Simulium virgatum chiapense Hoffmann: Only the female originally described. As far as I can discover no lectotype has been selected for this nor is it certain where the original material is now. The pupal filaments of *virgatum* were first figured in this paper under the name *virgatum chiapense*.

Simulium mathesoni Vargas: Holotype male, 1,400–1,500 m elevation, November 21, 1943, Temixco, Morelos, Mexico (A. Martínez P.). Instituto de Salubridad y Enfermedades Tropicales, Mexico. In addition to the holotype two pupae were also described.

DISTRIBUTION. *United States:* California: Alameda, Calaveras, Fresno, Lake, Los Angeles, Madera, Mariposa, Monterey, Napa, Placer, San Bernardino, San Diego, Santa Clara, Siskiyou, and Solano Counties. New Mexico: San Miguel County. South Dakota: Fall River County. Texas: Edwards, Medina, Travis, Uvalde, Williamson, and Zavala Counties. Utah: Grand, Utah, and Washington Counties. Washington: Yakima County. *Mexico:* States of Chiapas, Veracruz, and Chihuahua.

The above distribution is based only on specimens actually seen by me. Fairchild also reports it from Guatemala and Panama and Stains and Knowlton from Oregon. A recent

communication from Dr. Díaz N. lists the species under the name *rubicundulum* only from the states of Chiapas, Oaxaca, and Veracruz in Mexico. In view of the wide distribution of the species in the Western United States, it is strange that it has not been collected in the more northern states of Mexico. The extensive California records are mostly due to the col-



Figs. 1–10.—*Simulium virgatum* Coquillett and *S. solarii*, n. sp.: Genital fork of 1, *virgatum;* 2, *solarii.* Adminiculum of 3, *virgatum,* 4, *solarii.* Dististyle of 5, *virgatum,* 6, *solarii.* Cocoon of 7, *virgatum,* 8, *solarii.* Respiratory filaments of 9, *virgatum,* 10, *solarii.* Figs. 1–6 drawn to same scale.

lecting of T. H. G. Aitken and Bernard Brookman to whom I am indebted for material. Most of the Texas specimens were collected by me in April 1941.

Malloch placed *Simulium hippovorum* in a different group of species from *virgatum* because of the presence of hairs on the pleuron in addition to and anterior to the pleural tuft. It is true that the type of *hippovorum* does show distinct pale hairs at the top of the anterior anepisternum, while these are not present in the specimens of *virgatum* from Las Vegas Hot Springs. Material from Texas reared from apparently identical pupae shows these hairs present or absent and it is my opinion that this character has no real significance. Dyar and Shannon (1927) also mentioned the variability in this character. Malloch also stated that the claw of *hippovorum* is untoothed, but a distinct but small tooth is visible on all three pairs of legs. The type of *hippovorum* would go to *virgatum* in the key to females of Vargas and Díaz (1948). The genital fork of the female is exactly as figured by Hoffmann (1930) for *Simulium virgatum chiapense* and agrees with that of one of the females of the type series of *virgatum*, and with those of two specimens from Chiapas, Mexico.

The type of *rubicundulum* shows a few fine hairs on the anterior anepisternum on one side. The genital fork of the female is exactly as in *hippovorum* and the other examples cited in the preceding paragraph. It runs to *hinmani* in the key of Vargas and Díaz (1948), but in that species the handle of the genital fork has no knob at the base.

It is not certain what specimen was used by Dyar and Shannon (1927) in figuring the genital fork of *virgatum*, but it could have been from the type series. The figure is slightly inaccurate since it fails to show the abrupt knob at the base of the handle. The male genitalia are also poorly drawn, and it is impossible to determine from what specimen the drawings were made. The specimen listed from Clio. Calif., is not now in the *virgatum* collection, and so its identity can not be verified. That from Devils River, Tex., is the new species described in this paper.

The description and illustrations of *virgatum chiapense* show this to agree in every detail with the females of the type series of *virgatum*. It is not clear what Hoffmann took to be the type of *virgatum* when he compared *chiapense* with it, but he probably thought that Dyar and Shannon's figures were accurate.

There seems to be nothing to distinguish *Simulium mathesoni* from *virgatum*, the slightly more rounded shoulders of the adminiculum, as figured by Vargas, being found in some specimens of *virgatum*. A comparison of the species here treated as *virgatum* with males, females, pupae, and larvae of specimens from Córdoba. Mexico, determined as *mathesoni* by Vargas, and kindly sent to me for that purpose, show no differences of any consequence.

The female description and the distribution of the species as given by Stains and Knowlton (1943) agree with *virgatum*, but the male is the following species and will be discussed there.

Vargas, Martínez, and Díaz (1946) made two errors in discussing *Simulium virgatum*. The first was in stating that the name *virgatum* was proposed to replace the preoccupied name *Simulium cinereum* Bellardi. This was not the case, since it was described as a new species with no mention of *cinereum*. Secondly, they assumed that the figures by Stains and Knowlton of the male of *virgatum* were correct so they based their identification of *virgatum* on the wrong species and resurrected *rubicundulum* for the true *virgatum*. It is possible that *tephrodes* Speiser (1904), a substitute name for *cinereum* Bellardi, is the same as *virgatum* since Morelia, the type locality of *cinereum*, is not outside the range of *virgatum*, but until the type of *cinereum* can be dissected and studied there seems to be no possibility of fixing its identity. It is outside the known range of the new species here described, but not of several of the other species of the group.

The topotype females of *virgatum* run to *hinmani* in the key of Vargas and Díaz (1948), differing from that species in the same manner as did *rubicundulum* previously discussed.

Simulium (Dyarella) Solarii, n. sp.

Simulium virgatum Coquillett: Stains and Knowlton, Ann. Ent. Soc. Amer. **36**(2): 274, figs. 90, 91. 1943 (♂ only); Vargas, Martínez, and Díaz, Rev. Inst. Salub. y Enferm. Trop. **7**(3): 106, 111, 164, 180, figs. 161, 162. 1948 (♂, larva).

Male: Thoracic length 1.3 mm; wing length 3 mm. Antenna yellow-brown, the scape and pedicel paler; clypeus gray-pollinose with pale hair; proboscis yellow; palpus brown with

brown hair. Scutum dark reddish brown, with fine, pale yellow, appressed hairs, the humeri pale yellowish; a slender median and a pair of curved submedian dark lines on scutum; when viewed from in front a small, subrectangular pollinose spot on each side of the median line at anterior margin of scutum, and sublaterally a short curved pollinose line just outside of the curved dark line but extending posteriorly only a short distance; a velvety dark brown spot in front of wing base; scutellum slightly paler than scutum, with longer, nearly white hairs; postnotum dark brown with gray pollinosity; pleuron yellowish to dark brown with thin grayish pollen; no anepisternal hair tuft, the mesepimeral tuft pale yellow; stem of halter yellow-brown, knob white. Wing veins yellowish brown; hairs at base of costa mostly pale yellow, a few dorsally darker; hairs of basal vein brown; no hairs on vein R; fore coxa yellow, mid and hind brown; femora yellow, narrowly, obliquely darkened apically; fore tibia yellow-brown sometimes somewhat variegated with yellow, with pale pile; mid and hind tibiae yellow-brown, with basal and subbasal paler rings; fore tarsus dark; mid tarsus with basal three-fifths of first segment white, the rest dark; hind tarsus with basal halves of first and second segments white, the rest dark. First abdominal tergite yellow, the rest brown; sublateral spots of whitish pollen on some of the segments; sternites pale yellow. Genitalia dark brown, the dististyle large, broad, with both margins curved (Fig. 6); adminiculum with a short median projection and acutely pointed lateral angles (Fig. 4).

Female: Thoracic length 1.5 mm; wing 3.5 mm. Antenna yellow-brown, the scape and pedicel yellow; frons grayish-pollinose; clypeus yellowish brown with thin gray pollen and pale hair; palpus brown with brown hair. Scutum when viewed from in front pale reddish brown, with a very slender median dark line and a pair of narrow curved dark lines merging with a dark prescutellar area, and usually connected at their closest proximity near anterior third of scutum by a narrow dark, transverse line; viewed from behind the dark pattern becomes nearly white on a darker ground; humeri pale yellow; a dark brown, rather small, velvety patch in front of wing base; pleuron yellowish to brown with whitish pollinosity; no anepisternal hairs; mesepimeral tuft yellowish; halter yellow, the stem darkened. Wing veins yellowish brown; hairs at base of costa mostly pale yellow, some dorsally darkened; hairs of stem vein dark. Leg color essentially as in male, but foretibia more frequently somewhat variegated. Abdomen dark brown, with grayish posterolateral bands on most segments; last three tergites subshining, brown; paraprocts with coarse hairs over most of surface; genital fork as figured (Fig. 2); the end of the handle may be somewhat swollen, but usually not as abruptly or strongly so as in *virgatum*.

Pupa: Respiratory filaments (Fig. 10) 15, (14 paired and 1 single) about 1 mm long, held in a tight, forward-curving clump. Dorsum of thorax smooth with no spicules or rugosities. Cocoon (Fig. 8) with a smooth anterior rim and no narrow projections. Total length 4 mm; dorsal length 3 mm.

Larva: This is not described in full at this time because my knowledge of simuliid larvae is not sufficient to evaluate the significant characters. The submentum of this species, lacking strong, sublateral teeth has been figured by Vargas, Martínez, and Díaz (1946, figs. 161 and 162) under the name of *virgatum* and that of *virgatum*, with strong sublateral teeth (fig. 160) under the name of *rubicundulum*.

Holotype: Male, San Saba River, Menard County, Tex. April 23, 1941 (A. Stone no. 68).

Paratypes: *Texas:* Same as holotype, 2 ♂♂, 1 ♀; Los Morros Creek, Menard, May 22, 1939, 9 ♀♀ (Roy Melvin), April 12–14, 1943, 1 ♂, 2 ♀♀ (C. L. Smith), August 10, 1942, 2 ♂♂ (Roy Melvin); Menard, June 21, 1939, 2 ♂♂, 10 ♀♀ (Roy Melvin); Upper Little Walnut Creek, Austin, 1936, 1 ♂, 4 ♀♀ (A. B. Griffen); Nueces River, Uvalde County, April 21, 1941, 1 ♂, 3 ♀♀ (A. Stone no. 57); Frio River at Con Can, Uvalde County, April 21, 1941, 2 ♂♂, 11 ♀♀ (A. Stone no. 59–60); ex breast of horse, Con Can, July 29, 1914,; 25 ♀♀ (D. C. Parman & F. C. Bishopp); Uvalde, June 7, 1938, 8 ♂♂ (W. L. Barrett, Jr.), April 13, 1939, 2 ♂♂, 2 ♀♀ (Deonier & Barrett); at light, Devils River, Valverde County, May 5, 1907, 1 ♀ (Bishopp & Pratt); Junction, Kimble County, February 21, 1938, 1 ♂, 1 ♀ (F. C. Bishopp); Kerrville, Kerr County, April 6, 1948 (C. W. Sabrosky) 1 ♀; Shovel Mount, Burnet County, April 12, 3 ♀♀. *Mexico:* Xicotencatl, Tamaulipas, May 1944,

1 ♂, 1 ♀ (M. Macias G.); Las Cascadas, San Luis Potosí, December 22, 1943 (A. Díaz N.); wings, legs, and genitalia of male and female on slides. Holotype and paratypes, U.S.N.M. no. 58956; paratypes, Instituto Salubridade y Enfermedades Tropicales, Mexico.

Also in the Museum but not designated as paratypes are numerous larvae and pupae from Uvalde, Edwards, and Menard Counties, and the male genitalia from Austin mentioned below.

The name is derived from *solarium*, a balcony or terrace in the sun. This species appears to be most abundant in the Balcones Escarpment of Texas.

The figures of the male genitalia of *virgatum* published by Stains and Knowlton (1943) were apparently based upon a specimen of *solarii* from Austin, Tex. The slide from which I believe the drawings were made is labeled "Simulium virgatum Coq. Det. G. S. Stains 194, Austin, Tex. 10.18.22. Painter No. 60." Vargas, Martínez, and Díaz accepted these figures as correct and determined *solarii* in Mexico as *virgatum*.

The male of this species can be most readily distinguished from *virgatum* by the pale hairs at base of costa, the scutal pattern, the shape of the dististyle, and the acute lateral angles of the adminiculum. The female may be distinguished by the narrower curved stripes of the scutum, the usual connection between these near front of scutum, the usually paler hair at base of costa, the more extensively distributed hairs on the paraproct, and the shape of the genital fork.

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ZOOLOGY.—*Pharodinae, a new subfamily of Chondracanthidae (Crustacea: Copepoda), and a description of* Pharodes biakensis, *n. sp., from New Guinea.*[1]

Paul L. Illg, U. S. National Museum. (Communicated by Waldo L. Schmitt.)

The genus *Pharodes*, instituted by C. B. Wilson in 1935, was assigned to the family Chondracanthidae. The species proposed then, *P. tortugensis*, alludes to the vicinity of the Tortugas Laboratory, the locality of the original collection of six female specimens. These came from three common species of host fish. The series is preserved in the U. S. National Museum and has been used in the present study to provide amplification of generic and specific characteristics. This report adds to the genus *Pharodes biakensis*, based upon a single pair. These were found as parasites of a small reef fish, *Caracanthus unipinnus* (Gray), collected at Biak, New Guinea, by F. M. Bayer. Parasites and host have been deposited in the National Museum. The identification of the host was provided by Dr. L. P. Schultz, curator, division of fishes. Dr. Schultz also made available a series of examples of the host from various Pacific locations, but examination of these failed to yield further specimens of the parasite. The Biak specimens furnish the first description of the male for the genus.

The assignment of the genus to the Chondracanthidae is accepted, but the characters of *Pharodes* are so strongly distinctive and several represent sufficient departure from the anatomical details of hitherto described chondracanthids that it is considered appropriate to set forth its basic features as diagnostic of a new subfamily. The definition of the family Chondracanthidae then requires emendation to include these characters.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received August 5, 1948.

Family CHONDRACANTHIDAE Milne Edwards

Cyclopoida; in the female presenting suppression of segmentation and great expansion of the body into a fleshy mass with various protrusions. Body regions a cephalothorax, trunk and abdomen. Antennules inflated or prolonged, not prehensile. Antennae terminating in prehensile uncinate claws or tripartite anchoring structures. Upper lip a flat plate or produced medially as a proboscis-like tube. No lower lip. Mandibles reduced, falciform, usually two-segmented, margins with or without serrations, in some cases bearing rows of spinules. Maxillules reduced, palplike, or absent. First pereiopods prominent maxillipeds, borne on the cephalothorax. Swimming pereiopods variously reduced. Abdomen with caudal rami, of one or more segments; these may be unarmed or ornamented with one to several inconspicuous setae. Marked sexual dimorphism. Male body conforming more to the cyclopoid facies, but dwarfed and with great reduction of segmentation and appendages. Maxillae and maxillipeds of more prehensile nature than those of female. Abdomen small, segmentation suppressed.

This definition is mainly based on that of Oakley, 1930. A very slight departure from the earlier diagnosis is the acceptance here of the recently widely prevailing view of the second oral appendage as the vestigial maxillule, rather than as a mandibular palp. The information contained in the present study has no bearing on the partition by Leigh-Sharpe and Oakley of the chondracanthids known in 1928 as two subfamilies, the Chondracanthinae and the Lernentominae. These groups are here accepted as completing the family subdivision.

Pharodinae, n. subfamily

In the female, great expansion and inflation of the thoracic portion of the body, the abdomen reduced to a vestige placed relatively near to the midpoint of the thoracic mass. Oviducal openings ventral on the thorax at the level of the abdomen. Upper lip produced at its center into a prolonged, distinctly proboscislike tube, prolonging ventrally the food opening. Mandibles reduced, no marginal ornamentation. Maxillules absent. In the male, great inflation of the cephalothorax. Antennules and antennae placed well ventrally. A single pair of pereiopods, the maxillipeds.

One genus included, the type of the subfamily, *Pharodes* C. B. Wilson, 1935.

Genus **Pharodes** Wilson

Generic characters.—Female, head fused with segment of the maxilliped to form a cephalothorax. Dorsal carapace present. Main mass of body a trunk formed of thoracic segments coalesced and produced laterally and posteriorly as lobes and extensions. Abdomen borne ventrally as a vestige at about the midpoint of the trunk. Two pairs of pereiopods on the trunk, consisting of inflated, sac-like lobes. Male a dwarf, although not necessarily attached to the body of the female. Two main body regions, a roughly hemispherical cephalothorax and a narrow, short, curled, tail-like trunk. Antennule as in the female. Maxillae and maxillipeds of markedly prehensile nature.

Genotype.—*Pharodes tortugensis* Wilson, 1935.

Pharodes tortugensis Wilson

Only the female of this species has so far been collected. A partial revision of the characters as originally described as well as the addition of a number of details have been provided by the present study.

The usual chondracanthid character of great fleshy expansion and inflation of the body, accompanied by suppression and simplification of the appendages, is borne out in this form. Visible segmentation delimits two body regions—a head, actually a cephalothorax, since it bears maxillipeds, and a trunk, consisting of expanded thoracic somites. There is a sharply constricted neck. The characteristic appearance of the head is due to its expansion laterally, producing the aspect described originally as that of an inverted triangle. The middorsal surface of the head is set off as a highly chitinized carapace, apparently serving in part as a site of attachment for the considerably developed oral appendages.

The head is apparently freely moveable on the neck articulation. A position noted in several specimens was one of dorsal flexion, in the extreme producing nearly a right angle between the plane of the oral surface and the main axis of the body. In this position, the antennules and antennae protrude prominently, as seen in dorsal view. When the axis of the head is

aligned with that of the trunk, none of the appendages is visible dorsally.

The trunk, which actually is the free thorax, in dorsal view could be interpreted as a series of three globose enlargements, separated by constrictions and expanded laterally into variously developed lobes. Each of these three divisions, further, bears dorsally a rounded knob. The lateral processes of the first division are extremely extensive and flare out widely to the sides and then posteriorly, each nearly equalling in bulk the main mass of the thorax proper. The much less produced lateral processes of the second division are slightly curved, posteriorly directed, lappets. The lateral processes of the third division are just like those of the second, but exceed the latter somewhat in length. A posterior lappet, protruding directly posteriorly, also arises from the third division. This terminal division, with its pair of lateral lobes and single median projection, was interpreted originally as the abdomen. This view will be seen to be contradicted by further details of the present study.

All the contours of the dorsal surface are rounded and fleshy, as is characteristic among chondracanthids. In the original description, and cited as a generic character, it is stated that the posterior portion of the body is covered by two tripartite plates. The accompanying figure supported the description as given. However, comparison of the figure with the type specimen readily resolves the depicted appearance as the oversimplified linear rendition of the dorsally knobbed globular divisions with their lateral lobes and the posterior process. In agreement with other members of the Chondracanthidae, this genus possesses no rigid cuticular structures which might be interpreted as plates.

Ventrally, the subdivision of the free thorax or trunk is complicated by the inflated pereiopods and their basal structure. The expanded bases of the largest lateral lobes meet medially forming a ridge, the posterior edge of which roughly bisects the longitudinal axis of the trunk. Just anterior to this margin are the two flattened knobs which form the ornamentation of the oviducal openings, and between these is the slight eminence which is the vestigial abdomen. The posterior ventral portion of the trunk does not show distinct demarcation into globose segments as seen in dorsal view.

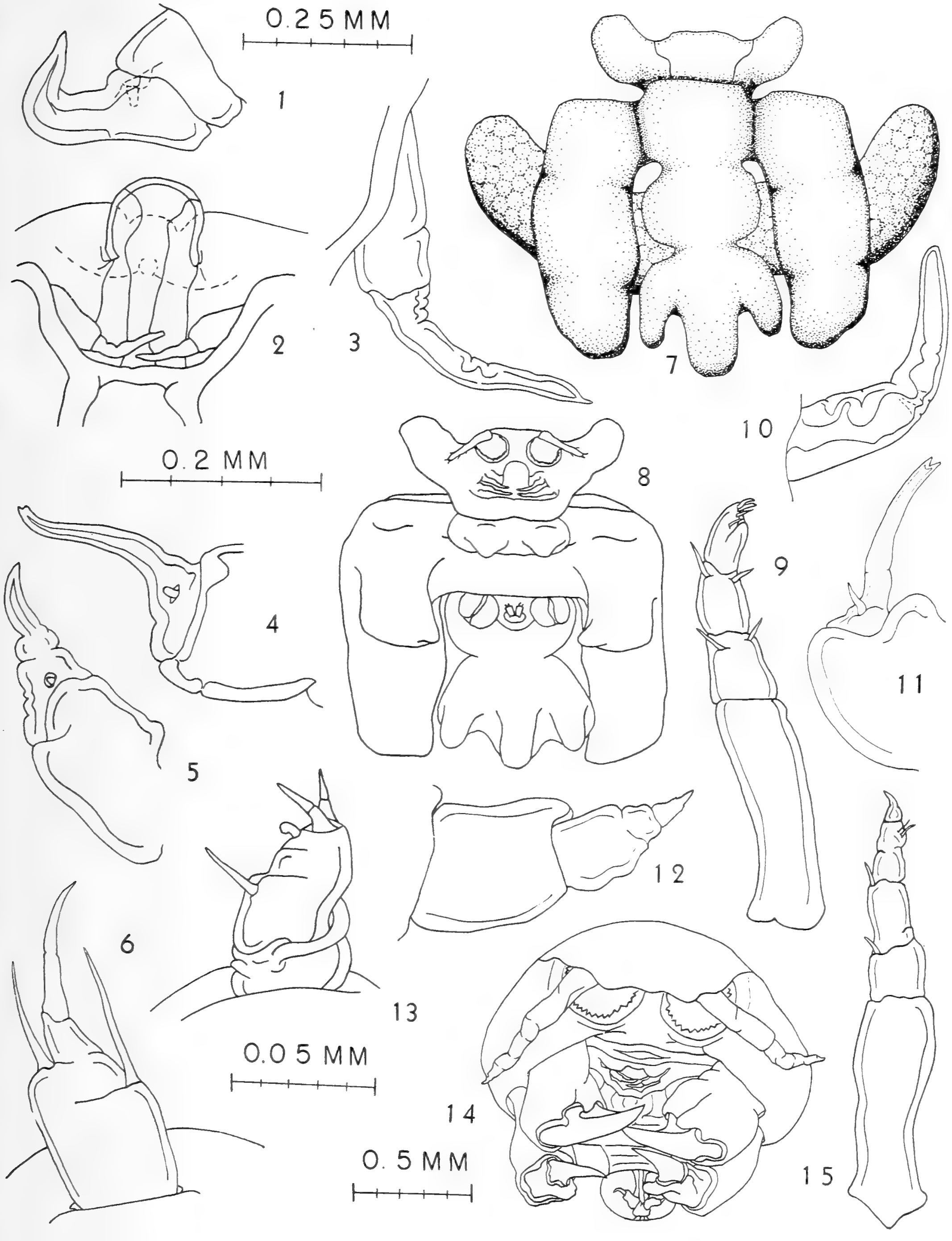
The antennules are very much unlike the usual inflated sacs characteristic of the family, bearing, rather, a greater resemblance to those found among the ergasilid parasites of fishes or among some of the chondracanthid males. They are strongly chitinized. The complicated articulations make it difficult to establish the segmentation accurately, but apparently there are four segments. The most distal segments are inconspicuously ornamented with a number of rather reduced setae.

The antennae (Fig. 1) are 2-segmented and strongly prehensile. The distal portion is a heavily chitinized, stout hook. As was pointed out in the original description, there is an inconspicuous outgrowth on the basal segment, representing perhaps a modified seta.

The upper lip is a most distinctive structure in the genus. It differs strikingly from the flattened crescentic plate of all the other members of the Chondracanthidae. Here there is a prolonged proboscislike structure, supported by a complicated chitinous framework and apparently capable of a limited amount of manipulation, as indicated by the presence of two slender muscle strands. The lateral margins are rolled and folded inward as thin chitinous flaps, forming a considerably prolonged mouth tube (Fig. 2). There is no comparable elaboration of an under lip. Posterior to the oral opening there is only an abrupt edge formed by the inturning of the integument of ventral surface of body.

The mandibles (Fig. 3) are so located that their bases are just lateral to the mouth. They are minute and inconspicuous, but distinctly of cyclopoid type. They differ from those of all other chondracanthids in the absence of marginal serration or spinulation. The surface of the mandible is very much thickened, but the constant appearance, in all preparations seen, of a much crumpled and wrinkled aspect would seem to indicate great flexibility rather than rigidity of the integument. The exact subdivision of the appendage, due to this wrinkling, is impossible to determine, but the appearance most consistently seems to indicate a 2-segmented condition, corresponding to the usual arrangement in nearly related copepods.

Examination of the limited material produced no evidence of the presence of maxillules. More refined dissections, when a larger number of specimens is available, may disclose the rudiments of these appendages among the complicated structures formed by the bases and chitinous supports of the mouthparts. The



FIGS. 1–6.—*Pharodes tortugensis* Wilson, female: 1, antenna; 2, oral area, showing upper lip and mandibles; 3, mandible; 4, maxilla; 5, maxilliped; 6, caudal ramus.

FIGS. 7–15.—*P. biakensis*, n. sp., holotypic female: 7, dorsal view; 8, semidiagrammatic drawing of ventral view; 9, antennule; 10, mandible; 11, maxilla; 12, maxilliped; 13, caudal ramus; allotypic male: 14, ventral view; 15, antennule.

The 0.25-mm scale refers to Figs. 1 and 15; the 0.2-mm scale to Figs. 2, 4, 5, 9, 11, 12; the 0.05-mm scale to Figs. 3, 6, 10, 13; the 0.5-mm scale to Fig. 14.

maxillae (Fig. 4) were described originally as maxillules (first maxillae). These are bimerous and heavily chitinized. The terminal segment is apparently rigid. It is tapered and presents a curved outline, faintly resembling the spout of a teapot. The tip is concavely truncate. This segment bears at its expanded base a minute accessory structure which may represent a modified seta.

The maxilliped (second maxilla of Wilson) is stout and is the most conspicuous of the mouthparts (Fig. 5). The highly irregular, thickly chitinized surface and the complicated articulations cause difficulty in determining the segmentation. There would seem to be three segments, the most distal produced into a strong, slightly curved, apical hook. The second segment bears a reduced, apparently articulated process.

The posterior limit of the area bearing the mouthparts is strongly set off by a prominent, rounded ridge, running in a gentle curve. Indentation at the midline produces a bilobed appearance of this ridge. It was interpreted in the original description as the vestige of the first pair of so-called swimming legs, that is, the non-oral pereiopods. There seems to be little ground to interpret these inconspicuous prominences as limb rudiments, although final decision will have to await the determination of the sequence of development in the larval stages. A necklike constriction just behind the described ridge strongly delimits the cephalothorax from the more posterior free thoracic region.

The ventral outgrowths of the trunk were interpreted originally as two pairs of thoracic limbs. There is no strong evidence other than their occurrence in pairs that these are limbs, but such a convention is regularly applied to other chondracanthids with similar structures. The first of these processes or limbs are set just to each side of the midline immediately posterior to the neck constriction. These are small knobs protruding considerably ventrally. More lateral to these, in fact well out toward the edges of the lateral processes of the first thoracic division, are the very much inflated second pair of trunk limbs. These are long and thick and directed slightly posteriorly.

Posterior to the pereiopods and slightly to each side of the midline are the oviducal openings. These are set off conspicuously by much enlarged perforated, disklike structures, to which the ovisacs are attached. Just between the oviducal structures is the rudiment of the abdomen, a minute eminence bearing tiny, but setiferous, caudal rami. These are most inconspicuous and very difficult of detection when the ovisacs are present. The reduced abdominal remnant is significant in the clarification it affords of the unique modification of the thorax. Among all the bizarre body forms seen in chondracanthid genera there is no other in which there is a comparable expansion of the thorax posterior to the genital openings. The enlargement is obviously occupied to a great extent by reproductive structures or tissues. The determination of the true segmentation of this region, if such could be derived from study of the ontogenetic stadia, should be of great theoretical interest.

The caudal rami (Fig. 6) are compressed, monomerous laminae. They are ornamented with small, but well-developed, simple setae. Each bears three setae, the stoutest of which is apically placed. Of the subterminal and most proximal of the setae, it was impossible to determine from available preparations which was dorsal and which ventral. The caudal rami are placed terminally on the reduced convexity which is the abdominal vestige.

The six specimens of the original series have been measured to establish roughly the characteristic proportions of the species. The total length and greatest width (to the edges of the lateral processes) of each were as follows: type specimen—3 mm long, 4.4 mm wide; specimen 2—3 mm long, 3.9 mm wide; specimen 3—3 mm long, 3.3 mm wide; specimen 4—2.8 mm long, 3.3 mm wide; specimen 5—2.8 mm long, 2.9 mm wide; specimen 6—3 mm long, 3.8 mm wide. In every case the greatest width was measured at a point practically at the posterior extent of the wide-flaring lateral processes of the first division of the trunk. A truncate triangular outline of the trunk mass would thus be seen to be characteristic for the species. In every specimen the lateral processes of the second trunk division were well developed and conspicuous.

An unpublished distribution record of the species is provided from the National collection. A single female was collected from the gills of *Scoliodon terrae-novae*, from the Gulf of Mexico, by C. B. Wilson, exact date and locality not known. A new host record is established also. As the specimen at some time had been sub-

jected to drying, it was not feasible to attempt to measure the bodily proportions.

Pharodes biakensis, n. sp.

Female (holotype).—The body consists of the head and trunk, a characteristic aspect being produced by the presence of expansions and lobes. The head bears a pair of processes which protrude considerably anteriorly as well as laterally, with the appearance of ear-like lobes. A middorsal chitinized carapace is present. Ventrally there is an elevation of the posterior margin of the cephalothorax as a low ridge, with a suggestion of bilobed division in the central portion. The trunk in dorsal view is a series of three globular sections, all in their main masses of roughly equivalent size. Of these, however, the first and third are further produced into processes. The processes of the first division are extended widely laterally and then produced posteriorly to an extent nearly equalling the length of the central trunk proper. Three low dorsal knobs appear serially along the longitudinal axis of each process. The second division of the trunk appears dorsally as a simple globe. The third division is globose, but is also produced posteriorly as an unpaired wide lobe. Further, it bears a pair of blunt lateral lobes, which curve considerably posteriorly as well as extending laterally. Fig. 7 depicts these details.

On the ventral side, the apparent segmentation is more complicated (Fig. 8). There is a distinct limit ventrally between the cephalothorax and the trunk but this juncture is compressed to a tightly closed groove in the type specimen. Just posterior to this is a transverse ridge, in extent of about half the width of one of the central trunk divisions. Laterally on this ridge are the paired ventral protrusions which represent the second pereiopods (counting the maxillipeds as first). Immediately posterior to this ridge is a second which extends across the main portion of the trunk and extends almost to the outer margin of each of the large lateral processes. This ridge is produced at its sides as the two large third pereiopods. These take a broad basal origin and protrude posteriorly and ventrally as long, thick, blunt lobes. In the ovigerous female these processes partially enfold the egg sacs. The medial portion of the second ridge cuts across the trunk at a level which would be about midway on the length of the second central division. However, the ventral segmentation of the anterior portion of the trunk is obscured by the complicated arrangement of ridges and outgrowths.

Lying at an oblique angle, directed ventrally and posteriorly, and fitted tightly against the posterior face of the second ridge, are the two prominences which surround the oviducal apertures. These thus are set on the ventral side of the posterior half of the second trunk division. Between the oviducal structures is the vestigial abdomen, bearing minute caudal rami. The constriction between the second and third central trunk divisions is fully visible ventrally. There is no complication of structures on the ventral side of the third trunk section.

The ovisacs are firmly attached on the discs surrounding the openings of the oviducts and are most characteristic in outline and position. The egg sac is a long, slightly tapering cylinder with a rounded tip and is curved along the longitudinal axis. Each thus extends laterally outward from just back of the midpoint of the body, protrudes considerably beyond the sides, and extends anteriorly to a level markedly in front of the point of origin. The eggs are minute and arranged in numerous, slightly irregular rows. The eggs contained in the pair of ovisacs number well into the thousands.

The dimensions (as well as the described aspect) of the single available specimen cannot be given with precision because of the markedly contracted position in which it is fixed. An attempt at establishing the relative proportions of the various parts and regions has been made, however. The total length is 3 mm. The greatest width is just slightly less than this. The parallel outer edges of the lateral processes give the outline of the main portion of the body pronouncedly squarish proportions. The lateral processes are 2.2 mm in length. The width of the head, from the edges of its processes, is 1.8 mm. The length of the head, along the central axis is .45 mm. The tips of the processes extend anteriorly about .15 mm beyond the central margin of the head. The width of the central globular mass of each of the trunk subdivisions is roughly 1 mm. The egg sacs measure 2.55 mm along the main axis and have a maximum diameter of about .75 mm.

The antennules (Fig. 9) are 4-segmented. The basal segment is longer than the terminal three together. It is three times as long as its greatest width, which is seen at two thirds of the length of the segment from its base. The

second segment is slightly longer than the third and about equal in length to the fourth. The segments decrease in their greatest widths in linear order. The antennule is not conspicuously inflated or saclike. A fairly heavy degree of chitinization is apparent and the articulations between segments are very complicated, indicating possibly some restriction as to planes of freedom of motion. There is a slight degree of compression of the appendage in the frontal plane of the body. The ornamentation consists only of reduced, inconspicuous setae. The basal segment seemingly lacks setae; the second and third each bear a lateral and medial seta at the distal corners. The terminal segment has a distal row of four, perhaps more, setae. The length of the antennule is 435 micra.

The single female specimen (as well as the accompanying male) had lost the antennae. Evidently these were sufficiently effective prehensile organs that they were completely torn away in the removal of the parasites from the host. Large, circular, articulating bases remain to indicate the proportion of the basal segment. It seems reasonable to assume that these appendages differ slightly, if any, from those of *Pharodes tortugensis*.

The upper lip is prolonged in the midline as a proboscis-like organ, with a folded-over, circular tip. In the intact specimen, the structure was held at approximately right angles to the body axis. The mouth opening lies just posterior to the upper lip with the bases of the mandibles set well to each side. The condition of the integument of the mandibles makes determination of the number of segments dubious but there are probably two. The base is rather stout and short, slightly longer than wide. The terminal portion is narrower and longer than the base, and consists of a slightly tapering cylinder with a bluntly rounded tip (Fig. 10). There is no serration of the margins, nor any detectable ornamentation. The length of each mandible is approximately 125 micra. No maxillules could be found.

The bimerous maxillae (Fig. 11) are much larger than the mandibles. The proximal segment is wide and short, its articulation with the main body mass forming a steep slant across its breadth. The length of the segment along its center axis is about 100 micra. The integument is heavily sclerotized. Internally are numerous bands of muscle attached to the base of the terminal segment, which forms an angle of attachment of about 90 degrees. The distal segment is expanded basally, then constricted sharply to a prolonged, slightly tapered, rigid terminal process, 200 micra in length over all. The tip is truncate and sharply indented. A short, stout seta is borne on the base of this segment.

The maxillipeds (Fig. 12) are characterized by great thickening of the integument. This causes difficulty in establishing the segmentation accurately. There is a large, clearly delimited basal segment, 150 micra long, with a width of 45 micra. This roughly rectangular, slightly curved, segment has a distinctly subterminal articulation with the remaining portion of the appendage, which is of the same total length. The most probable interpretation of this distal section would be as a single segment, 110 micra in length, bearing distally a distinctly articulated, blunt spine 40 micra long. At a level about 75 micra from its base this section exhibits transverse furrows of the integument and interruptions of the internal bands of muscle which would seem strong evidence of coalescence of an originally bimerous structure. The greatest width of the terminal section is slightly greater than half that of the proximal segment. The distal half of the terminal section is tapered sharply to the base of the articulated spine.

The trunk pereiopods are fleshy lobes, with little semblance remaining of articulated appendages. Those of the anterior pair are placed close to the midline and are far anterior on the trunk. They are very short lobes protruding directly ventrally. The slightly more posterior third perieopods (second pair of trunk appendages) are very long fleshy lobes, 1.1 mm in length, and each is placed well out on the anterior lateral process of the trunk.

The caudal rami (Fig. 13) are laminae, compressed in the sagittal plane of the body. The ornamentation of each consists of two terminal setae, placed close together; a rounded process, which is possibly a modified seta, placed somewhat subterminally; and a long slender seta placed slightly beyond the midpoint of the ramus. Whether this most proximal seta is dorsal or ventral on the ramus could not be made out from the available preparation. Each caudal ramus is 55 micra long, with the greatest dorsoventral measurement slightly over 40 micra. The rami are borne very close together on a low convexity, placed between

the eminences bearing the oviducal apertures. This convexity, with its appendages, constitutes the vestige of the abdomen. At a point one fourth of its length from its base each ramus is conspicuously marked on the surface by elaborate chitinous convolutions. These do not seem to constitute a complete subdivision of the ramus into a bimerous condition. The exact significance of this complicated integumentary pattern remains doubtful.

Male (allotype).—The cephalothorax is greatly arched and rounded dorsally, and its general outline is ellipsoidal. The narrow trunk, consisting of an indeterminable number of thoracic and abdominal segments forms a curled tail-like process, of only a quarter of the width of the cephalothorax. The greatest width of the cephalothorax is 1.4 mm. The length along the central axis is 1.1 mm. The trunk is nearly parallel-sided, 0.41 mm in length and about 0.3 mm in width, with a short wide flaring at the point of juncture with the cephalothorax.

All the appendages of the cephalothorax are placed well on the ventral side (Fig. 14). The antennules (Fig. 15) are markedly subapical and their bases are widely spaced laterally. Each is 650 micra long. The number of segments is here interpreted to be four, although complicated grooving of the integument distally makes it impossible to determine the articulations exactly. The basal segment is distinctly set off. It is slightly longer than the rest of the segments together. It is 350 micra in length and the width at the most expanded point is just one third of this measurement. The second segment is 100 micra long and 85 micra wide at the widest point. The third segment is markedly narrower than the preceding, measuring 55 micra in width and 80 micra in length. The remainder of the appendage is 135 micra long and measures 45 micra at the greatest width, at the base. This sector tapers gradually and terminates, by a sharp constriction, in a slender spine. The exact metamerism is obscure, but this portion seems to represent a coalescence of three segments or perhaps of two segments and an articulated spine with a greatly expanded base. Complete details of the ornamentation were not made out. The second and third segments each bear a distal seta. The distal segment, in addition to its apical spine, bears two reduced subterminal setae.

The antennae of the single specimen were lost in removal from the host. Of considerable significance here is the fact that this male was not attached to the body of the female as is the usual case among the chondracanthids. The basal scars left by the tearing away of the antennae were comparable to the same artefacts in the case of the female.

The upper lip is produced considerably ventrally, but does not take the tubular proboscislike form like that seen in the female. The mandibles, as in the female, are inconspicuously placed anterior to the bases of the larger and more prominent remaining oral appendages, and are set to each side of the rather large mouth opening. The mandibles measure about 120 micra in length. They are slender, tapering falciform appendages, with no ornamentation. No trace of maxillules detected.

The maxillae present the appearance of exceedingly powerful prehensile organs. The basal portion is a stout segment, about 300 micra in length and of slightly greater width. Set at nearly right angles on the distal surface of this segment and directed medially is a very massive claw, 400 micra long. This claw tapers from a base about 275 micra in width to a keenly pointed, stoutly spinous apex. The whole appendage is heavily sclerotized, and the terminal claw appears to be nearly completely solid.

The maxillipeds are tripartite. The basal segment is about 450 micra long and has a maximum width of about 300 micra. The outline of the segment is roughly rectangular. The second segment is so articulated on the first as to be directed considerably medially and ventrally. It is about 200 micra long and its width is about 175 micra. On its distal surface is set a strong, tapered claw. The base of the claw is about 125 micra in extent. Its length is 250 micra and it curves in a smooth taper to a stout point. This appendage, like the preceding, is heavily sclerotized. No other thoracic appendages could be made out.

The caudal rami are minute, roughly rectangular, about 90 micra long, and each bears apically a rather stout, short, tapered seta. The rami are borne on a broadly flattened area at the tip of the tail-like trunk. There is no evidence from the adult condition for determining the degree of inclusion of anatomically thoracic or abdominal segments in the trunk structure; except, of course, that the tip, in bearing the caudal rami, is marked as of abdominal origin.

Type locality.—Biak Island, Schouten Islands, Netherlands New Guinea.

Types.—Holotypic female, U.S.N.M. no. 86009, and allotypic male, U.S.N.M. no. 86010; from the gill cavity of *Caracanthus unipinnus* (Gray), collected April 3, 1945, by F. M. Bayer.

Remarks.—The two species of *Pharodes* unfortunately must be based upon an extremely small number of representatives. When more adequate series are available and the range of variability of the two forms is established, it may well be that some of the distinguishing features found here will be discarded as no longer significant. However, the consistent conformation to the structure of the chondracanthids in general, in various forms of which extensive information as to variability is available, is good grounds for the prediction that the differentiation of these forms will continue to be supportable.

Pharodes biakensis is easily separated from *P. tortugensis* by a number of features of body form. The more extreme production of the lateral processes of the head, the much more nearly quadrate aspect of the main mass of the body with its expansions, and the lack of a pair of lateral processes on the second division of the trunk provide a ready basis of recognition of the former.

The differentiation of the appendages in the two species is in the main a series of subtle variations on a basic plan of structure. In the female *Pharodes biakensis*, as compared to its congener, the mandible is shorter in proportion and somewhat more blunt apically. The maxilla bears a well-developed accessory seta, represented in *P. tortugensis* by a modified element of characteristic appearance. The maxilliped exhibits a greater suppression of segmentation and the terminal spine is somewhat slighter and simpler. The caudal rami have a different pattern of armature and an indication of subdivision.

The sexual dimorphism in *Pharodes biakensis* has a number of features of interest by comparison with the condition in other chondracanthids. The general rule is a by far greater absolute size disparity. The male is typically a minute dwarf and usually is to be found attached on or near the genital aperture of the female. In *Pharodes* the male is of large size and obviously is capable of independent existence on the host. Also worthy of note is the fact that the antennule, maxilla, and maxilliped of the male reach actually greater absolute dimensions than the counterparts in the female. The basically similar pattern of structure of the antennules in the two sexes is a contrast to the usual chondracanthid situation of an inflated sac-like appendage in females and a less modified male antennule. The scars remaining indicate that the antennae were of about equivalent size, at least at the base, in the two sexes. The mandibles show little disparity. The different degree of development of the tubular upper lip indicates the highly special character of the modification as seen in the female.

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ZOOLOGY.—*Two new species of polychaete worms of the family Polynoidae from Puget Sound and San Juan Archipelago.*[1]

MARIAN H. PETTIBONE, University of Washington. (Communicated by WALDO L. SCHMITT.)

The two new species of Polynoidae herein described were obtained in connection with a study of the scaled Polychaeta in the San Juan and Puget Sound region. The work was carried out at the University of Washington Oceanographic Laboratories, Friday Harbor, Wash. Dredging was carried out from the M.S. *Catalyst* and M.S. *Medea.* The types are deposited in the United States National Museum.

Family Polynoidae

Genus **Harmothoë** Kinberg

Harmothoë hartmanae, n. sp.

Fig. 1, *a–f*

This species is represented by three speci-

[1] Received September 8, 1948.

mens from material dredged in the San Juan Archipelago. I take pleasure in naming it after Dr. Olga Hartman, who has done so much to add to our knowledge of the Polychaeta.

Description.—The type (U.S.N.M. no. 21101), the largest of the three specimens, has 37 segments. It is 23 mm long, 6.5 mm wide exclusive of setae, and 9.5 mm wide inclusive of setae. The smallest of the paratypes is 8.5 mm long and 2 mm wide exclusive of setae. The body is short, nearly linear, widest in segments 12–23, tapering slightly anteriorly and posteriorly. The body is without color in the middorsum, greenish on the cirrophores and the parapodia. The ventral surface is shiny iridescent and without color except for a dark coloration around the mouth.

Fifteen pairs of elytra nearly cover the dorsum and are slightly imbricated, arranged on segments 2, 4, 5, 7, 9 . . . 23, 26, 29, and 32. The elytra are subcircular to subreniform in shape, thin, and shiny, appearing smooth, but furnished with conical blunt microtubercles (Fig. 1, *c–d*). A dark border completely encircles the first pair of elytra and around the posterior, median, and lateral borders of the other elytra. Microscopically, this border appears as darker polygonal areas (Fig. 1, *d*).—not present on *Harmothoë imbricata* (Linnaeus)—the widespread cosmopolitan species. The elytral border is smooth except for a few short filiform and clavate papillae.

The bilobed prostomium is wider than long, has a wide anterior median sulcus and prominent cephalic peaks; the four eyes are large, the anterior pair situated anteroventrally and slightly posterior to the peaks (Fig. 1, *a*). The median antenna has a large brown ceratophore and a long slender style with a slight subterminal enlargement and very short scattered clavate papillae; the style is dark, especially above and below the enlargement. The lateral antennae have short brown ceratophores, inserted ventrally on the prostomium; the styles are brown, short, tapering gradually to filiform white tips and furnished with very small papillae. The palpi are long—up to five times the length of the prostomium, slender, and with short papillae.

The proboscis has the usual polynoid form, with nine pairs of distal papillae and two pairs of amber-colored interlocking jaws; it extends the length of the first 12 segments; the proximal half may be darkly colored. The segmental papillae begin on segment 6 and continue posteriorly; they are very small and bulbous in the more anterior and posterior segments but long and cylindrical in the segments of the middle third of the body.

The basal lobes of the tentacular segment are elongated, each bearing two setae; the tentacular cirri are similar to the median antenna (Fig. 1, *a*). The dorsal cirri have elongated cirrophores with a bulbous base and narrower distal part; the styles are long, slender, similar to the median antenna, and extend beyond the tips of the setae. The dorsal tubercles of the cirri-bearing segments are prominent conical lobes. The ventral cirri are thick proximally, tapering to filamentous tips (Fig. 1, *b*).

The parapodia are biramous. The notopodium is a rounded lobe on the anterodorsal face of the neuropodium, extending out into an acicular lobe from which the aciculum projects (Fig. 1, *b*). The notosetae are golden, moderate in number (about 40), forming a spreading bundle, thicker than the neurosetae (45–62μ in greatest diameter), slightly arched, with long spinous regions—about half the exposed length—and bare pointed tips (Fig. 1, *b, e*). The neuropodium tapers distally to a thick acicular lobe from which the aciculum projects (Fig. 1, *b*). The neurosetae are golden, moderate in number, and more slender than the notosetae (16–44μ in diameter in the stem region: 22–48μ in the enlarged distal part). The supraacicular group of neurosetae (about 12 in number) are the longest, with long spinous regions (20–24 rows), and a strong secondary tooth on all the setae; the subacicular group (about 26) range from longer dorsal to shorter ventral ones, with short spinous regions (12–14 rows), and with a strong secondary tooth except on the lower ventral ones (Fig. 1, *f*).

Remarks.—*Harmothoë hartmanae* resembles the cosmopolitan species, *H. imbricata* (Linnaeus). It differs chiefly in the character of the elytra as described above.

Locality.—The specimens were dredged west of Crane Island in the San Juan Archipelago in 20 fathoms on a shelly bottom.

Genus **Lepidasthenia** Malmgren

Lepidasthenia berkeleyae, n. sp.

Fig. 2, *a–f*

This species is represented by three specimens taken from three places in the south end of Puget Sound—in Carr and Case Inlets. I am

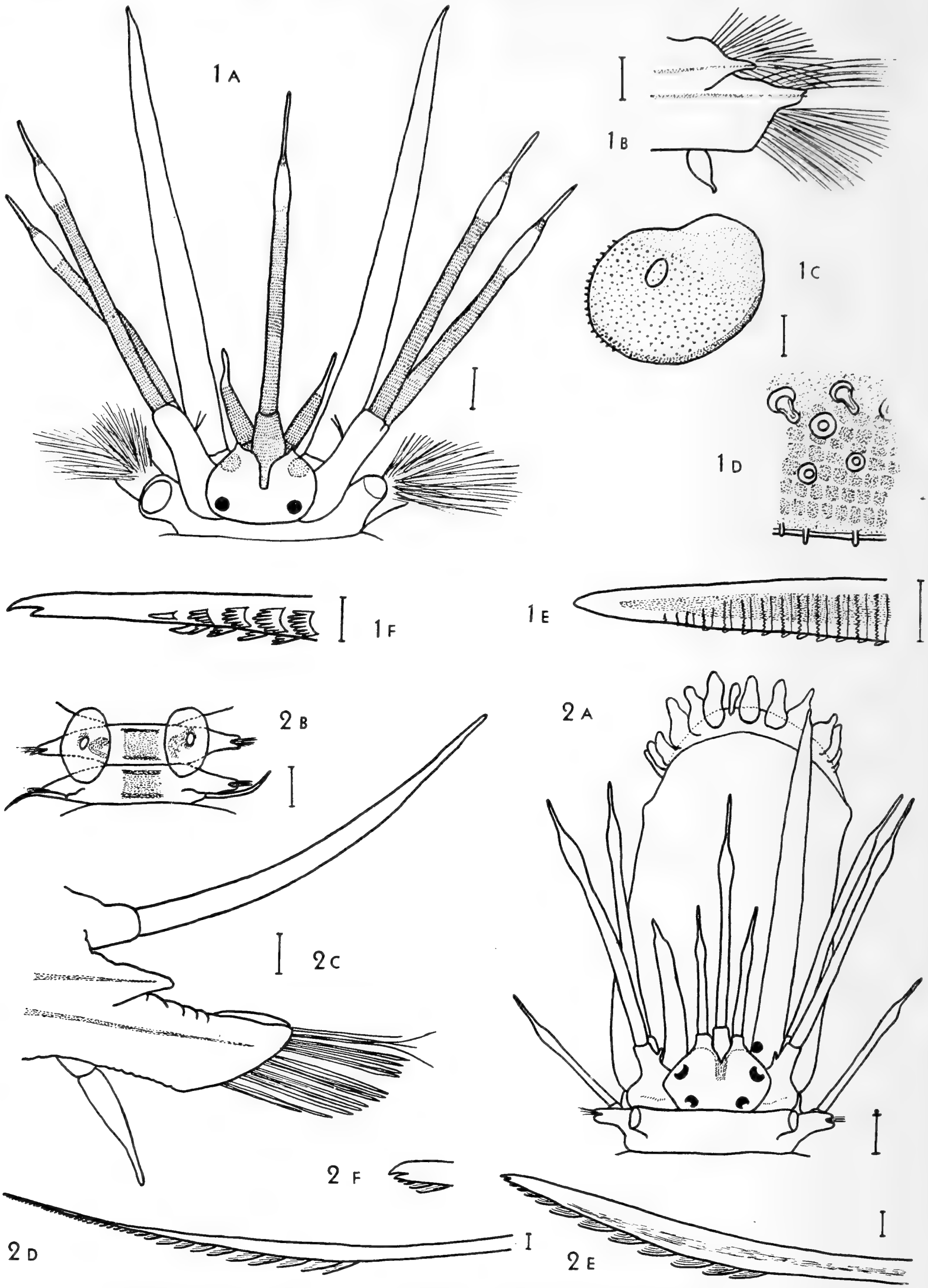

FIG. 1.—*Harmothoë hartmanae*, n. sp.: *a*, Dorsal view prostomium and first two segments, elytra removed; *b*, sixteenth left parapodium, anterior view; *c*, fourth left elytron; *d*, part of posterior border of elytron, enlarged; *e*, tip of notoseta; *f*, tip of middle subacicular neuroseta.

FIG. 2.—*Lepidasthenia berkeleyae*, n. sp.: *a*, Dorsal view prostomium, first two segments, and extended proboscis, with elytra removed; *b*, dorsal view two segments from anterior third of body; *c*, twenty-second left parapodium, anterior view; *d*, dorsal neuroseta; *e*, middle neuroseta; *f*, tip of same.

Scale measurements as follows: 1*a*, 1*b*, 2*c* = 0.43 mm; 2*a*, 2*b*, 1*c* = 0.95 mm; 1*d* = 30μ; 1*e* = 48μ; 1*f* = 38μ; 2*d* = 9μ; 2*e* = 15μ.

naming this species after Edith Berkeley. She and her husband, Cyril Berkeley, are workers on the Polychaeta and have established the commensal host of this species. *Lepidasthenia berkeleyae* resembles *L. longicirrata* Berkeley (Berkeley, 1923, 1942), a species that has been found in the Puget Sound region also. The differences are referred to in the text. E. and C. Berkeley consider *L. berkeleyae* to be the commensal form of *L. longicirrata* and not a distinct species (Canadian Pacific Fauna: Polychaeta Errantia. In press). They have found it commensal with the mud tube-dwelling polychaete, *Praxilella affinis* (Sars) var. *pacifica* Berkeley (family Maldanidae).

Description.—The type (U.S.N.M. no. 21099), of some 100 segments, is complete, although the posterior end of 23 segments was regenerating. The two paratypes are incomplete anterior ends (70 and 54 segments). The type, of 100 segments, is 75 mm long, 4 mm wide excluding setae, and 6 mm wide including setae. The body is flattened dorsoventrally, long, narrow, with sides nearly parallel, tapering slightly anteriorly and posteriorly. Each segment has a wide transverse middorsal brown band, the anterior and posterior part of which may be darker. The basal part of the parapodia, the cirrophores and elytrophores are darkly pigmented. The body is more darkly pigmented anteriorly than posteriorly. The ventral surface is without color. (The ventral surface lacks the globose papillae found on *L. longicirrata.*)

The 37 pairs of elytra of the type are arranged on segments 2, 4, 5, 7, 9 . . . 23, 26, 29, 32, 34, 37, 40 . . . every third segment to the end of the body. The elytra are small, oval, and do not nearly cover the dorsum but leave a median longitudinal zone uncovered—about equal to the width of an elytron (Fig. 2, *b*). (In *L. longicirrata,* the elytral pairs are larger and practically cover the dorsum.) The elytra are thin, transparent, blotched with brown pigment, especially around the place of attachment to the elytrophore and the area medial to it.

The bilobed prostomium is much wider than long, with a distinct anterior median sulcus (Fig. 2, *a*). The four eyes are large, the anterior pair being larger and located just anterior to the greatest width of the prostomium. The lateral antennae are inserted terminally on short anterior prolongations of the prostomium; the styles are slender, approximately equal in length to the greatest prostomial width, and have slight subterminal enlargements and filamentous tips. The median antenna has a short ceratophore; the style is slender, long—about twice the prostomial width—and with a fine filamentous tip. The palps of one paratype are missing; those of the type and the other paratype have one long slender palp—about three times the greatest prostomial width—and one shorter one (probably regenerating). Antennae and palps are without color or papillae.

The proboscis has the usual polynoid form, with nine pairs of distal papillae and two pairs of dark amber-colored interlocking jaws; it extends the length of approximately the first 12 segments. The paired segmental papillae begin on segment 6 and continue posteriorly; they are short and bulbous.

The large basal lobes of the tentacular segment are each furnished with an aciculum which projects in a short achaetous fingerlike process; the paired tentacular cirri are similar to the median antenna (Fig. 2, *a*). The anterior few pairs of dorsal cirri resemble the median antenna; the more posterior cirri are slender, transparent, evenly tapered, and extend slightly beyond the tips of the setae (Fig. 2, *c*). The paired ventral cirri of the second segment are long, slender, similar to the tentacular cirri (Fig. 2, *a*); those of the following segments are short and subulate (Fig. 2, *c*). The paired anal cirri are similar to the dorsal cirri.

The parapodia are moderately long and slender. The notopodium is a short, fingerlike, achaetous lobe, furnished only with an aciculum; the tip of the lobe does not nearly reach the dorsal cleft of the neuropodium (Fig. 2, *c*). (This is in contrast to *L. longicirrata* in which the notopodial lobe is more elongate and the tip extends to the dorsal cleft of the neuropodium.) The distal end of the neuropodium has a dorsal cleft; the lobe anterior to the cleft and the one which contains the aciculum is only slightly longer than the posterior lobe (Fig. 2, *b–c*). (In *L. longicirrata,* the anterior lobe is decidedly longer than the posterior lobe.) The neurosetae are of two kinds: (1) a dorsal group of setae (about four in number) are elongated, slender (10 μ in greatest diameter), with long spinous regions, tapering distally to fine tips (Fig. 2, *d*); (2) a median and ventral group of setae (18–25 in number) are shorter, stouter

(10–19μ in greatest diameter—the more ventral ones being shorter and thinner); they have short spinous regions (8–12 rows), with no bare distal tips; the distal tips are bifid—the secondary tooth blends in with the spinous rows or it may be inconspicuous (Fig. 2, *e–f*). (This is in contrast to *L. longicirrata* in which the middle neuropodial setae are distinctly bifid, with bare distal tips.)

Habitat.—The specimens were dredged from mud in 35 to 70 fathoms. E. and C. Berkeley (in correspondence) have found them commensal in the mud tubes of the polychaete *Praxilella affinis* (Sars) var. *pacifica* Berkeley. (This is in contrast to *L. longicirrata* which is usually found free in dredge material. However, on two occasions, I found them within parchmentlike tubes, agglutinated with bits of shell and rock—a tube evidently of their own making.) The extreme delicacy of the elytra and body would indicate a somewhat protected habitat for both species.

Locality.—Type: off Green Point, Carr Inlet, 51 fathoms in mud. Paratypes: near Gertrude Island, Carr Inlet, 70 fathoms in mud; off Herron Island, Case Inlet, 35 fathoms in mud.

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ZOOLOGY.—*American Caudata, V: Notes on certain Appalachian salamanders of the genus* Plethodon.[1] M. B. MITTLEMAN, New Rochelle, N. Y. (Communicated by HERBERT FRIEDMANN.)

The action of Pope and Hairston (1948: 106–107) in describing two nominally new races of salamanders, *Plethodon shermani rabunensis* and *P. s. melaventris*, reflects a taxonomic viewpoint radically opposed to that of Grobman (1944) and some other workers. As pointed out by their describers, *rabunensis* and *melaventris* have been "for many years . . . identified as *P. metcalfi*: more recently by Grobman as *P. clemsonae*." Obviously, the status and proper allocation of Pope and Hairston's new forms are contingent upon the definitions of the species *clemsonae* and *metcalfi*.

Based on topotypic material, the structural characters of *clemsonae* may be summarized as follows: Costal grooves 15 or 16 (including inguinal and axillary branches of the first and last grooves); appressed toes sometimes meeting, but more often separated by one or two costal folds; vomerine teeth 9–12 per series. The color characteristics of *clemsonae*, which are so important in differentiating it from certain other related species of *Plethodon*, have been subject to considerable discussion. Brimley's original description (1927: 73–74) shows that some of his type specimens had white or grayish dorsal markings when fresh, while others were uniformly black on all dorsal surfaces. Two topotypes collected by Arnold Grobman and myself possessed whitish-gray (ashy) lichenoid markings in life, which were particularly prominent along the sides of the head and body (see Bishop, 1943: fig. 64). Grobman has discussed (1944: 294) the possibility that the absence or presence of light pigments in *clemsonae* may be associated with the length of preservation, as is occasionally the case in such species as *Plethodon richmondi*, *P. nettingi*, and *P. welleri*. This is, of course, a distinct possibility, but it is likewise true that some *clemsonae* are quite immaculate; pigmentation in *clemsonae* is evidently subject to some variation, as in other species of *Plethodon*. The color characteristics of *clemsonae* are a black dorsum and belly (belly varying from almost pure black to a very dark slaty gray), with the throat (and occasionally the anterior part of the breast) whitish or grayish, with a grayish white pattern of irregular lichenoid maculations sometimes present on the dorsum and sides of the head and body.

Brimley's type of *metcalfi* is an adult

[1] Received September 9, 1948.

male (snout-vent 60 mm), with 15 costal grooves, no costal folds between the appressed toes, 11 or 10 vomerine teeth, uniform bluish above and grayish tan or fawn below. Salamanders agreeing closely with this type are known from southwestern North Carolina (Haywood County) north through the southern Blue Ridge Province to Beartown Mountain (4,500–4,700 feet) near Burkes Garden, Tazewell County, Va. (Hoffman and Kleinpeter, 1948: 603), and Mount Rogers (5,000–5,600 feet); Grayson County, Va. (collected by Hoffman and Kleinpeter). On the other hand, specimens from more southerly and westerly points in the Carolinas and Georgia possess characteristics that identify them with *clemsonae*, as described above. As pointed out originally by Grobman (1944), these dark-bellied "*metcalfi*" are in fact conspecific with Brimley's *clemsonae*, and the two forms—the light-bellied *metcalfi* and the dark-bellied *clemsonae*—occupy predominantly vicarious ranges (1944: fig. 5). The distribution of *clemsonae* extends from Macon, Jackson, and Transylvania Counties, N. C., to Pickens and Greenville Counties, S. C., and Rabun and Habersham Counties, Ga.

Pope and Hairston (*loc. cit.*) have described certain specimens of the dark-bellied *clemsonae* from Rabun Bald Mountain, Rabun County, Ga., as *Plethodon shermani rabunensis*, diagnosing their new salamander as "a member of the *jordani-metcalfi* group with white spots on the cheeks and along the sides of the body. The legs are never red as in *B. s. shermani*." The description points out further that the type (adult female, 118 mm total length, snout-vent 62 mm) has 13 costal grooves and vomerines 10–7, and that "the color is black above, shading into dark gray below; the throat is paler than the belly." As given, the description of *rabunensis* offers no tenable point of difference to distinguish this nominal subspecies of *P. shermani* from *P. clemsonae*, except for the presence of 13 costal grooves (as compared to 15 or 16 in *clemsonae*). Yet even this apparent difference is illusory, and arises as a result of the method used in counting costal grooves, rather than indicating a true meristic difference. In order to obtain the full costal groove count in *clemsonae* the axillary and inguinal branches of the first and last grooves must be counted. Sometimes these are poorly developed or obscure as a result of preservation; if they are not included, a count of 13 or 14 is obtained, rather than 15 or 16. In practice, most herpetologists use the "maximum count" method, which includes the axillary and inguinal branches. Hence, with the apparent costal groove count difference negated, there appears to be no salient difference between *rabunensis* and *clemsonae*, and I conclude that these forms are identical.

The status of Pope and Hairston's new *P. shermani melaventris* likewise seems poorly established. In this instance the race is diagnosed as "An immaculate member of the *jordani-metcalfi* group with a black belly." The type is further described as being an adult male (total length 116 mm, snout-vent 60 mm), with 14 costal grooves, 10 or 11 vomerine teeth, body and limbs immaculate black above and below, throat gray; Pope and Hairston state also that their 112 paratypes from Macon, Jackson, and Transylvania Counties, N. C., exhibit no significant variation. The range of *melaventris* is given as extending from Swannanoa, Buncombe County, N. C., to Greenville County, S. C., and westward to Highlands, Macon County, N. C. As in the case of *rabunensis*, the description of *melaventris* offers no characters to set it apart from *clemsonae*, save for the costal groove count, and this again reflects a method of counting rather than a real difference.

The fundamental difference between *metcalfi* and *clemsonae* lies in the ventral pigmentation, as previously discussed. In addition, *metcalfi* is a slightly longer-toed form, occasionally having one costal groove between the appressed toes, but more often none, while in *clemsonae* there is usually at least one groove between the toes, and only rarely do the toes meet or overlap (in adult specimens). Of the two, *metcalfi* tends to have shorter vomerine series, the range of vomerine teeth counts in specimens I have seen being 6–12, average 8.1,

whereas in *clemsonae* the variation is 6–16, average 9.1. The examination of several series of salamanders from the vicinity of Highlands, Macon County, N. C., reveals considerable variation in the degree of intensity of the belly pigment. For example, in a series of specimens from Mirror Lake, near Highlands, U.S.N.M. no. 88010, female (snout-vent 58 mm), has an immaculately black back and belly, as do also U.S.N.M. no. 88014 male (snout-vent 56 mm), and no. 88016, female (snout-vent 58 mm). On the other hand, three smaller specimens taken at the same time and locality (U.S.N.M. nos. 88011–13, all males, snout-vent 40, 49, 46 mm) have black dorsums and light grayish throats, but dark yellowish gray bellies. Similarly, in U.S.N.M. nos. 104527–31, from Little Yellow Mountain, 4,100 feet, near Highlands, two large females and a male (snout-vent 50, 63, and 60 mm, respectively) have black backs and bellies, while two smaller females (snout-vent 39 and 44 mm) have gray bellies. Another specimen, U.S.N.M. no. 72825, female, Whiteside Mountain, near Highlands (snout-vent 67 mm), is black above and dark slaty gray below. Specimens I have seen from Rabun and Habersham Counties, Ga., and Pickens County, S. C., are uniformly black above and below (except for the throat), from immaturity (snout-vent 35 mm) to maximum adult size (snout-vent 80 mm), although they occasionally have grayish or grayish-white fleckings on the head and body. Taken in their entirety, the variations of *metcalfi* and *clemsonae*, as well as the vicarious ranges and apparent intergradation in Macon County, N. C., make it evident that these two forms are allopatric races of the same species and accordingly should be recognized as *Plethodon metcalfi metcalfi* and *P. m. clemsonae*. The consistent types of ventral pigmentation that characterize the two races within their respective ranges, and the apparent association in part between size (age) and degree of belly pigmentation in some Highlands specimens, may indicate not only intergradation in the vicinity of Highlands but may also be taken to indicate in ontogenetic fashion the phylogenetic process which has resulted in the derivation of *clemsonae* from *metcalfi*.

While the arrangement suggested above satisfies the situation so far as the majority of known specimens is concerned, two specimens are known that fall completely outside this system. These two examples, U.S.N.M. nos. 127523–4, were collected by H. J. Cole, on Black Mountain, ca. 4,000 feet, Harlan County, Ky. One (no. 127523) is a sexually mature female (snout-vent 56 mm), while the other (no. 127524) is an immature male (snout-vent 39 mm). Both specimens are a uniform rich black above and below, including the chin, throat, and breast, except for a very few tiny, isolated light flecks, and have whitish palms and soles. In both specimens the costal count is 15, and the toes overlap, while the vomerine count is 12–14 in the female specimen and 10–10 in the male. In color and dentition these specimens are indistinguishable from *clemsonae*, except for the uniformly black throat, while the overlapping toes might suggest *metcalfi*. On purely geographic grounds it would be expected that they would fall in the scope of *metcalfi;* that they do not, and appear instead to be more nearly identifiable with *clemsonae*, raises a point of major importance. It is possible that additional specimens from this locality would provide sufficient characteristics to distinguish a separate form. But for the present, the status of these Kentucky specimens is not properly determinable; a reasonable decision as to their identity must await additional material from this critical area.

ACKNOWLEDGEMENTS

Owing to the kindness of Dr. Doris M. Cochran I have had available the extensive collections and other facilities of the United States National Museum; for this, and many simi'ar courtesies, I am in Dr. Cochran's debt.

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ICHTHYOLOGY.—*A new name for* Synchiropus altivelis *Regan, with a key to the genera of the fish family Callionymidae.*[1]

Leonard P. Schultz and Loren P. Woods, U. S. National Museum.

During the course of our study of the fishes of the northern Marshall Islands it was necessary to review the genera of callionymid fishes of the world. We observed that *Synchiropus altivelis* Regan [Trans. Linn. Soc. London **12**: 249, pl. 30, fig. 1. 1908 (Seychelles); Norman, John Murray Exped. 1933–34, Sci. Repts. Fishes, **7** (1): 75, fig. 27. 1939 (Gulf of Aden)] is preoccupied by *Callionymus altivelis* Temminck and Schlegel [Fauna Japonica, p. 155, pl. 79, fig. 1. 1845 (Japan)], now *Synchiropus altivelis* (T. and S.). We herewith propose the new name *Synchiropus normani* to replace *S. altivelis* Regan, 1908.

Although Fowler (Proc. U. S. Nat. Mus. **90**: 1–2. 1941) gave a key to the genera, new facts have been found that require us to present our different analysis, with synonyms of genera. The species of this family have not been revised, and they are in a general state of confusion, somewhat as a result of the differences between sexes. We do not have the time or the specimens necessary to revise carefully the several dozen species named but believe our analysis of genera will aid in referring most or all of the species to a defined genus. We have examined the 54 lots of types and paratypes of this family along with numerous other nontype specimens in the National Museum. That material forms the basis of the following key:

Key to the Genera of Callionymidae

1a. Two dorsal fins.

2a. No pelvic ray free or separate from others, all connected by membrane.

3a. Two lateral lines, lower one represented by a fleshy keel or membranous fold along lower side of body beginning opposite anterior base of anal fin; opercular membrane ending in a free flap; posterior part of maxillary semitubular in form, convex side inward, open side outward, with a very short anterior and outwardly projecting concave lobe, scarcely developed in small specimens; opercular opening superior in position, above opercle, in form of a small foramen; pelvic fins connected to pectoral base by a membrane attached opposite base of 4 to 6 pectoral rays from dorsal edge of fin; upper lateral line simple; no orbital tentacle; preopercular spine acute with small spines dorsally and a small antrorse spine basally; soft dorsal and anal rays all unbranched except last one in each fin which is branched to base........... *Calymmichthys*[2] Jordan and Thompson

3b. A single lateral line located mostly in dorsal part of body, no thin fold of skin along lower side.

4a. An orbital tentacle in combination with a broad somewhat fleshy lower lip folded under chin; opercular opening a small foramen above opercle; no free opercular flap; pelvic membrane attached to base of pectoral fin; lateral line simple; preopercular spine acute with spiny points dorsally and an antrorse spine ventrally and somewhat basally; all rays of soft dorsal and anal fins un-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received August 13, 1948.

[2] *Calymmichthys* Jordan and Thompson, Mem. Carnegie Mus. **6**(4): 296, pl. 36, fig. 2. 1914 (genotype, *C. xenicus* Jordan and Thompson). Their figure lacks the lower lateral line described twice in the text.

Diacallionymus Fowler, Proc. U. S. Nat. Mus. **90**: 29. 1941 (genotype, *Callionymus goramensis* Bleeker).

Dermosteira Schultz, U. S. Nat. Mus. Bull. 180: 267, fig. 26. 1943 (genotype, *D. dorotheae* Schultz); We believe *C. cookei* Günther belongs in this genus.

branched except last one in both fins branched to its base . . . *Amora*[3] Gray

4*b*. No orbital tentacle, or if a small one occurs the lower lip not broadly folded below chin.

5*a*. Pelvic fin membrane absent, no membrane connecting pelvic fin with pectoral base; preopercular spine without a basal antrorse spine.

5*b*. Pelvic membrane present and joined with base of pectoral fin near its middle; no free opercular flap; gill opening a small foramen above opercle; lateral line simple; no orbital tentacle.

6*a*. Opercle ending in a free dermal flap; gill opening in a superior position at rear of opercle; lateral line without elongate side branchings; body very robust; all rays of soft dorsal and of anal unbranched except last one, which is branched to base in both fins . . . . *Eleutherochir*[4] Bleeker

6*b*. No free opercular flap of skin; gill opening superior in position, above opercle; all rays of anal unbranched except last, which is branched to its base.

7*a*. Lateral line with short branches at right angles; all rays of soft dorsal unbranched except last, which is branched to its base . . . . *Paracallionymus*[5] Barnard

7*b*. Lateral line simple; soft dorsal rays branched and last one to its base . . . . *Yerutius*[6] Whitley

8*a*. Preopercular spine with a basal antrorse spine or one near its ventral edge; all rays of dorsal and of anal fins unbranched except the last one in both fins which is branched to its base. . . . . *Callionymus*[7] Linnaeus

8*b*. No antrorse spine at base or on ventral side of preopercular spine; first soft dorsal ray usually unbranched, all rest branched (except in young), the last one to its base; anal rays unbranched except last one, which is branched to its base. . . . . *Synchiropus*[8] Gill

2*b*. First pelvic ray not connected by a membrane with the next ray; gill opening behind opercle . . . . *Dactylophus*[9] Gill

1*b*. Dorsal fin single, spiny part lacking; gill opening superior in position at rear of opercle; pelvic membrane not connected with pectoral base; lateral line simple; orbital tentacle lacking; no antrorse spine near basal part of preopercular spine; soft dorsal rays branched, last one to its base; anal rays unbranched, except last one, which is branched to its base . . . . *Draculo*[10] *Snyder*

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[3] *Amora* Gray, Illustrations of Indian zoology, Hardwicke, **2**: pl. 90, fig. 1. 1833–34 (genotype, *Amora tentaculata* Gray = *Anaora* Gray, *ibid.*, probably typographical error for *Amora* in directions for arranging plates). (Reference copied.) We refer *Synchiropus tentaculatus* Herre (Philippine Journ. Sci. **35**: 33, pl. 3. 1928) as a synonym of *Amora tentaculatus* Gray. *S. tentaculatus* Herre is a homonym also, but since we do not consider it as distinct from *tentaculatus* Gray, we see no reason to propose a new substitute name. In addition *Callionymus fimbriatus* Herre (Herre Philippine Exped. 1931: 94. 1934) is a synonym of both *tentaculatus* Gray and *tentaculatus* Herre, in our opinion.

[4] *Eleutherochir* Bleeker, Versl. Medel. Akad. Wet. Amsterdam, ser. 2, **14**: 103. 1879 (genotype, *C. opercularioides* Bleeker).

Brachycallionymus Herre and Myers, *in* Herre, Proc. Biol. Soc. Washington **49**: 12. 1936 (genotype, *B. mirus* Herre = *C. opercularioides* Bleeker).

[5] *Paracallionymus* Barnard, Ann. Mag. Nat. Hist., ser. 9, **20**: 69. 1927, and Ann. South African Mus. **21**: 448. 1927 (genotype, *C. costatus* Boulenger).

[6] *Yerutius* Whitley, Rec. Austral. Mus. **18**: 115. 1931 (genotype, *C. apricus* McCulloch).

[7] *Callionymus* Linnaeus, Systema Naturae, ed. 10: 249. 1758 (genotype, *C. lyra* Linnaeus).

Calliurichthys Jordan and Fowler, Proc. U. S. Nat. Mus. **25**: 941. 1903 (genotype, *C. japonicus* Houttuyn).

Repomucenus Whitley, Austr. Zool. **6**: 323. 1931 (genotype, *C. calcaratus* Macleay).

Callimucenus Whitley, Suppl. checklist fishes New South Wales, ed. 3, no. 398: 418. 1934 (genotype, *C. macdonaldi* Ogilby).

Velesionymus Whitley, *ibid.*: 418 (genotype, *C. limiceps* Ogilby).

[8] *Synchiropus* Gill, Proc. Acad. Nat. Sci. Philadelphia, 1859: 129. 1860 (genotype, *C. lateralis* Richardson).

Foetorepus Whitley, Austr. Zool. **6**: 323. 1931 (genotype, *C. calauropomus* Richardson).

[9] *Dactylophus* Gill, Proc. Acad. Nat. Sci. Philadelphia 1859: 130. 1860 (genotype, *C. dactylophus* Bennett = *D. bennetti* Gill).

Vulsus Günther, Catalogue of the fishes in the British Museum **3**: 15. 1861 (genotype, *C. dactylophus* Bennett).

[10] *Draculo* Snyder, Proc. U. S. Nat. Mus. **40**: 545. 1911 (genotype, *Draculo mirabilis* Snyder).

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